THE MICROSCOPIST.

THE

MICROSCOPIST;

OR,

A Complete Manual

ON THE

USE OF THE MICROSCOPE:

FOR

PHYSICIANS, STUDENTS,

AND ALL

LOVERS OF NATURAL SCIENCE.

WITH ILLUSTRATIONS.

BY

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TO

PAUL BECK GODDARD, M.D.,

DISTINGUISHED BY

HIS ARDENT AND SUCCESSFUL PROSECUTION

OF

THIS AND KINDRED STUDIES,

This Work

IS RESPECTFULLY INSCRIBED

BY

THE AUTHOR.

PREFACE.

SINCE the employment of achromatic instruments, microscopic research has ceased to be merely an amusement, but has been elevated to the dignity of a science; yet, so far as the author knows, no book has been issued from the American press which would serve as a guide to those desirous of applying themselves to such studies.

The present work aims to supply this deficiency. In its preparation the author has aimed less at style than at information. Its matter has been condensed into the smallest possible space, so that it may be, what its title professes, "A Complete Manual on the Use of the Microscope." It does not supersede the necessity of more elaborate works, especially in the departments of Minute Anatomy and Pathology, but gives directions by which such works may be more profitably employed by the student. The multiplied labours of many observers have been classified and arranged, and free use has been made

of English authorities, so as to bring the work up to the present standard of information ; at the same time the opinions and experience of the author have been stated without hesitation.

Respecting the construction of the Microscope itself, a brief description is all that was deemed necessary ; nor could it have been much more extended without being liable to serious objection. As to the employment of the instrument upon the various objects of science, as full an account has been given as was consistent with brevity ; and to make this department more complete, reference has been made to the doctrines and discoveries of modern Physiology and Pathology.

The work is committed to the notice of the scientific community with the hope that it may prove of service in the study of the wonderful works of the Great Creator, who is "all in all, and all in every part ;" whose Power and Wisdom are seen as well in the minutest atom as in the most gigantic masses ; and whose government embraces not only intelligent free agents, but also the smallest animalculæ existing in a drop of stagnant water.

CONTENTS.

THE MICROSCOPIST.

CHAPTER I.

FROM the earliest period of scientific research, the magnify-
ing properties of lenses have been used to penetrate the arcana
of nature, and with most striking results. A vast amount of
information, which could have been obtained in no other way,
has been added, by microscopic observation, to almost every
branch of natural science.

To the Christian philosopher, the microscope reveals the
most amazing evidence of that Creative Power and Wisdom
before which great and small are terms without meaning. He
rises from the contemplation of the minutiæ which it displays,
feeling more strongly than ever the force of those beautiful
words—" If God so clothe the grass of the field, which to-day
is, and to-morrow is cast into the oven, shall he not much more
clothe you? O ye of little faith!"

To the geologist, it reveals the striking, yet humbling fact,
that the world on which we tread is but the wreck of ancient

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organic creations. The large coal beds are the ruins of a
luxuriant and gigantic vegetation; and the vast limestone
rocks, which are so abundant on the earth's surface, are the
catacombs of myriads of animal tribes which are too minute
to be perceived by the unassisted vision. It exhibits, also,
that metallic ore, as the Bog Iron Ore, and immense layers of
earthy and rocky matter, are formed merely by the aggregation
of the skeletons or shields of Infusoria; while beds of coral
rocks are still in the process of formation, the architects being
tiny marine polypi. Further, by this instrument, the nature
of gigantic fossil remains is often determined, and by it they
are assigned their true place in the classification of the
naturalist.

To the student of vegetable physiology, the microscope is an
indispensable instrument. By it he is enabled to trace the
first beginnings of vegetable life, and the functions of the dif-
ferent tissues and vessels in plants.

The zoologist finds it also a necessary auxiliary. Without
it, not only would the structure and functions of many animals
remain unknown, but the existence of numerous species would
be undiscovered.

It is to the medical student and practitioner, however, that
the microscope commends itself for its utility. A new branch
of medical study—histology—has been created by its means
alone; while its contributions to morbid anatomy and physi-
ology, or pathology, are indispensable to the student or phy-
sician who would excel, or even keep pace with the progress of
others, in his profession. To such the following remarks will
doubtless be interesting.

Histology is that science which treats of the minute or ulti-
mate structure and composition of the different textures of
organized bodies. It is derived from ἰστὸς, a tissue or web, and
λογος, a discourse.

The attempts made by the early microscopic observers to determine ultimate structure, were in general of little value, partly on account of the imperfections in the instruments employed, and partly from the mistakes they made in judging of the novel appearances presented to their view. This last cause of error still exists, and inexperienced observers may very readily be led astray. By such, a fibre of cotton upon the stage of the microscope, moving in obedience to the hygrometric influence of the breath or of a moist atmosphere, might be regarded as a living animal; or the influence of various reagents on pus, mucus, blood, or other matters, might lead to error. This last was the case with the celebrated Borelli, who was the first to apply the microscope to the examination of structure.

Borelli was born in 1608, and lectured as professor in the University of Pisa in 1656. In his day a general idea prevailed, that diseases were occasioned by animalculæ existing in the animal tissues and fluids. An examination of abnormal fluids with the microscope favoured this idea, as the globules were immediately taken for living beings. Borelli described the pus globules as animalcules, and even says he has seen them delivering their eggs. It will be seen that this was a very natural mistake, when we remember that these globules contain several minute granules, which make their escape when the external envelope is broken or dissolved. In this way we often find the germs of truth in the curious speculations of the early microscopists.

Malpighi was the first to witness the most beautiful sight which the microscope can reveal,—the actual circulation of the blood, thereby demonstrating the reasoning of Harvey to be true. The first work he published, in 1661, comprises his microscopic observations relative to the structure of the lungs. Between this period and 1665, he published other tracts on

the minute anatomy of the kidneys, spleen, liver, membranes
of the brain, &c., and several of the structures still retain his
name. He also paid attention to the anatomy and transforma-
tions of insects, the development of the chick in the egg, and
the structure of plants. It will be perceived from the last
remark, that the intimate connexion between animal and vege-
table physiology was even then acknowledged. This connexion
has led to the establishment of the cell doctrine, or the theory
of the development of all organized tissues from cells.

Lewenhoeck has sometimes been called the father of micro-
graphy. He was born at Delft, in Holland, in 1663, and
appears to have received a rather indifferent early education.
He first brought himself into notice by the skill with which
he ground glasses for microscopes and spectacles, and for im-
provements in those instruments; thus affording a good model
for microscopic observers: first attending to the optical and
mechanical construction of the instrument he was to employ. In
1690 he discovered and demonstrated the capillary blood-vessels.
He opposed the chemical doctrines which then reigned in medi-
cine, which attributed disease to fermentation in the blood.
He objected; that if fermentation existed, air bubbles would be
seen in the vessels, which was not the case. He showed that
the blood-globules were of different sizes and forms in various
tribes of animals; examined the brain and nerves, the mus-
cles, the crystalline lens, the milk, and numerous other textures
and fluids; and made the interesting discovery of the sperma-
tozoa, which he conceived to be of different sexes. There can
be no doubt that he made numerous errors, but the whole sub-
ject being new, his errors were excusable; and his contributions
to science are still of the highest interest.

Swammerdam, Lyonet, and Ellis, after this period, greatly
extended our knowledge of the lower tribes of animals; while

Lieberkuhn, Fontana, and Hewson laboured successfully in the department of histology.

To Lieberkuhn we owe the first good account of the anatomy of the villi, and of the minute tubular glands of the small intestine, which still bear his name. As a minute injector he has never been surpassed.

Fontana examined the brain, nerves, muscles, and several other textures, with great care, and his observations were extremely accurate.

Hewson is celebrated for his accurate observations on the blood and lymph corpuscles. He first demonstrated that the blood-globules were flat, with a central nucleus, and not round, as had been previously supposed.

Nearly all the celebrated men alluded to, made use of the simple microscope. At this period the compound microscope was very defective. It was more of a toy than a scientific instrument.

From an ignorance of many phenomena connected with the microscope which are now well understood, many errors resulted. Optical illusions were mistaken for natural appearances, as was the case with Monro. In his discoveries respecting the brain and nerves, he describes them as being formed of convoluted fibres, and in his examination of other textures he saw the same fibres and always mistook them for nerves. The fact was, that he made his observations while the direct rays of the sun were transmitted through the substance under examination, and the optical phenomena which were produced led to the mistake. He afterwards found them on the surface of metals, and then frankly acknowledged his error.

Another source of early errors was the treatment to which their preparations were subjected before examination. It is now well known that animal tissue should be examined while fresh and transparent. What result is it possible to draw from

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the observations of those who boil, roast, macerate, putrefy, triturate, and otherwise injure the delicate tissues? Most of the tissues contain albumen, which, so treated, gives origin to globules, and flakes of different forms; a circumstance which has led several anatomists to conceive the basis of animal structures to be globular. Several late observers have also made this mistake.

Messrs. Todd and Bowman, the learned authors of "The Physiological Anatomy and Physiology of Man," present the following sensible remarks respecting this subject,—"To make microscopical observation really beneficial to physiological science, it should be done by those who possess two requisites: an *eye*, which practice has rendered familiar with genuine appearances as contrasted with those produced by the various aberrations to which the rays of light are liable in their passage through highly refracting media, and which can quickly distinguish the fallacious from the real form; and a *mind*, capable of detecting sources of fallacy, and of understanding the changes which manipulation, chemical reagents, and other disturbing causes may produce in the arrangement of the elementary parts of various textures. To these we will add another requisite, not more important for microscopical than for other inquiries; namely, a freedom from preconceived views or notions of particular forms of structure, and an absence of bias in favour of certain theories, or strained analogies. The history of science affords but too many instances of the baneful influence of the *idola specûs* upon the ablest minds; and it seems reasonable to expect that such creatures of the fancy would be especially prone to pervert both the bodily and the mental vision, in a kind of observation which is subject to so many causes of error, as that conducted by the aid of the microscope."

The invention of the achromatic object-glasses for micro-

scopes formed the beginning of a new epoch in histological pursuits.   Since that period, the confusion and opposition which formerly existed among observers have diminished, and at present only those differences remain which are incident to the pursuit of any other branch of scientific study.

In our own times, the Germans seem to have taken the lead in histological observations ; and the reputation of the well-known names of Ehrenberg, Müller, Schwann, Schulz, Wagner, Weber, and Valentin, principally depends on the discoveries they have made by means of the microscope.

In England, the names of Carpenter, Todd, Bowman, Owen, Cooper, Busk, Quekett, Bowerbank, and others, are connected with microscopic research.

In our own country, a spirit of emulation seems excited, which promises great advantage.   Professor Bailey of West Point, and our townsmen, Drs. Leidy and Goddard, may be mentioned among others who have contributed to this result. The recent lectures of Dr. Goadby (late minute dissector to the Royal College of Surgeons, England), on microscopic science, have done much to increase a desire on the part of medical students and others to become practically acquainted with this subject.   His lectures to the students of the Philadelphia College of Medicine, and at other places, were well attended ; as likewise were his private classes.   Of his valuable suggestions I have frequently availed myself.

The advantage of a practical acquaintance with the microscope by medical men may be easily seen, and is readily acknowledged.   Dr. Bennet, of Edinburgh, to whom I am indebted for much of the histological part of this introduction, says—" I have lately had many opportunities of satisfying myself that death may be occasioned by structural changes in the brain, which are altogether imperceptible to ordinary vision, and which have escaped the careful scrutiny of the first morbid

anatomists in this city. Again, who would have imagined that
porrigo favosa, mentagra, aphtha, and other diseases, consist of
cryptogamous plants growing on the skin or mucous mem-
branes? Surely facts like these hold out a strong inducement
to the histologist who prosecutes pathological inquiries.'' In
another place he relates the following circumstance, which tends
to illustrate the same point: "A gentleman who had an ab-
scess in the arm, observed one morning his urine to be turbid,
and to deposit a considerable sediment. The practitioner who
attended him thought it looked like purulent matter, but before
finally forming his diagnosis, he asked me to examine it with
the microscope. I did so; but instead of finding pus corpus-
cles, discovered a large quantity of irregularly formed granules,
which I recognised to be fibrinous. I immediately suggested
that the abscess was on the point of resolution, and I after-
wards learned, that from that time it rapidly disappeared.
The fact that fibrin, exuded into the tissues, and, subsequently
absorbed, passes off by the kidneys, was determined by the
microscopic observations of Schönlein and Zimmerman in Ger-
many.''

Many other instances might be adduced, were it necessary,
to show the importance of the microscope in diagnosis and in
practical medicine. It is not too much to hazard the assertion,
that in a few years the practitioner will find it as essential in
finding out the nature of disease, and the state of the system,
as the most valuable articles of the materia medica are useful
in medical treatment. The following example will illustrate
the delicacy as well as utility of this mode of investigation.
A few evenings since, while entertaining a friend with some
microscopic views, he expressed a wish to see the red globules
of the blood; so, pricking the tip of his finger with a lancet, a
drop was extracted, which, after covering with thin glass, was
placed upon the stage of the microscope. Observing the glo-

bules, with a greater tendency than usual, to run together into rows, like piles of coin, I remarked to him, that his blood assumed an inflammatory or a feverish appearance. He replied, that he had been for about thirty-eight hours without sleep, having sat up with a sick friend the night before, and having some gastric irritation in addition, he had felt feverish all the evening. Observations on pus, mucus, the urine, and the various forms of malignant tumours, &c., all exhibit the value of this instrument to medical science.

In medico-legal researches the microscope has already proved a valuable auxiliary. It has several times been employed to ascertain the true nature of spots suspected to be blood-stains, &c.; and in cases where human life was suspended upon its decision.

In 1837, M. Ollivier was directed to ascertain whether any human hair was attached to the blade of a hatchet seized in the house of a person suspected of murder, and if this were the case, to determine the colour of the hair. With the microscope, M. Ollivier ascertained that the filaments attached to the hatchet were the hairs of an animal, and not of a human being; and this was afterwards fully proved.

CHAPTER II.

THOSE who have examined a common magnifying glass (or lens) know that it is necessary to hold it exactly at a certain distance from the object viewed through it, in order that such object may be seen with distinctness. The point at which the object must be placed is called the *focus* of the lens, and the distance from the middle of the lens to the focus is the *focal length,* or focal distance of the lens.

The cut represents sections of the different forms of lenses. A, is a plano-convex lens. B, double convex. C, plano-concave. D, double concave. E, a meniscus.

Fig. 1.

A   B   C   D   E
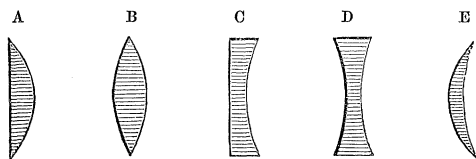
The effect of the convex lens or of the meniscus is to cause the rays of light which pass from any object through them, to converge towards a point or focus; and the eye receiving those

rays after passing through the lens, sees the object apparently magnified.   This principle is the basis upon which all microscopes are constructed.

The concave lens produces a precisely contrary effect to that described above.   The rays of light diverge on passing through it, and the object appears diminished in size.

SIMPLE MICROSCOPES.

A plano or double convex lens, especially when mounted, or arranged with conveniences for viewing objects, is called a simple microscope.

The magnifying power of a simple microscope is in proportion to the shortness of its focal length.   Thus, a lens of 2 inches focal distance, magnifies 5 diameters (or the superficies 25 times)—of 1 inch focus, 10 diameters—$\frac{3}{4}$ths of an inch, 15 diameters—$\frac{1}{2}$ inch, 20 diameters—$\frac{1}{4}$ inch, 40 diameters—$\frac{1}{8}$th inch, 80 diameters—$\frac{1}{10}$th inch, 100 diameters.

This table of magnifying powers is not invariably correct, owing to the difference of vision in different individuals, but it is sufficient for all practical purposes.

Simple microscopes are mounted in a variety of ways, according to the purposes for which they are intended.   Some are made to turn upon a hinge into a case, so as to carry in the pocket; and others are fixed on a handle, with a pin or small pair of forceps in the focus, on which a small object, as an insect, &c., may be placed.

The cut, Fig. 2, exhibits the arrangement of Dr. Withering's Botanical Microscope, which is valuable from its simplicity. It consists of three brass plates, a, b, c, parallel with each other,

to the upper and lower of which the stout wires, *d*, *e*, are rivet-
ted.   The middle plate, *b*, which forms the stage for carrying
the objects, is made to slide up and down on these wires. The
upper plate, *a*, carries the lenses, *i*, and the lower one, *c*, some-
times carries a mirror, for reflecting the light of a candle or of
the sky through any transparent object which may be placed
on the stage.   Into the stage a dissecting knife, *h*, a pointed

Fig. 2.
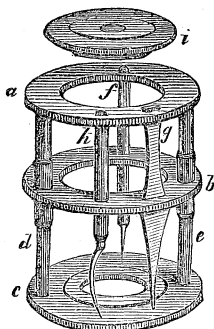
instrument, *f*, and a pair of forceps, *g*, are made to fit, and can
be readily taken out for use by sliding the stage down nearly
to the mirror.
     A very useful kind of simple microscope was that invented
by Mr. Wilson ; an early form of which is represented by Fig.
3. The body, A, A, A, A, which was made either of ivory, brass,
or silver, was cylindrical, and about two inches in length, and
one inch in diameter.   Into the lower end, B, the magnifiers
are screwed, and into the upper end screws a piece of tube, D,
carrying at the end, C, a convex glass, and on its outside a
male screw.   Three thin plates of brass, E, are made to slide

easily in the inside of the body to form the stage. One of these plates, F, is bent semicircularly in the middle, for the reception of a tube of glass, for viewing the circulation of the

Fig. 3.
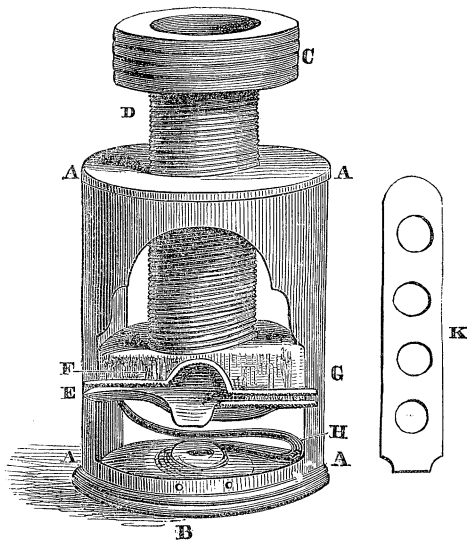
blood in small fish, while the other two are flat, and between these last the object-sliders, K, are introduced. Between the stage and the end of the body, B, is a bent spring of wire, H, to keep the stage and object steadily against the screw-tube. The object is adjusted to the focus by turning the screw D. This instrument was held in the hand in such a position that the light of a lamp or candle might pass directly into the con-

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densing glass. It was afterwards improved by the addition of a handle placed at right angles to its body.

The best form of the simple microscope for viewing opaque

Fig. 4.
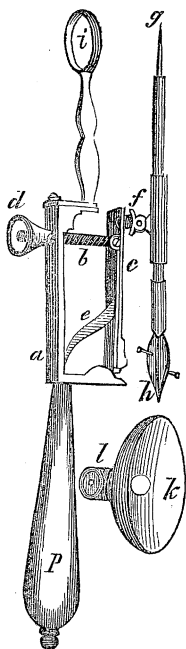
objects, is that represented by Fig. 4 : *a* is a flat piece of brass attached to the handle, *p* ; it supports the lens-holder, *i*, and through it passes the screw, *b*, which is connected to the back-plate, *c* ; a spring, *e*, keeps the plates, *a*, *c*, apart, and the nut,

d, adjusts the lens to the focus of the object, either on g or h. But the chief merit in its construction consists in a concave speculum or mirror of silver, k, highly polished, to the centre of which, at l, the magnifying glass is adapted. This is screwed into the ring i, and so held that a bright light, as from a candle or white cloud, is received upon the speculum (called a Lieberkuhn, from the name of its inventor). The light so received is concentrated upon the object, which is brightly illuminated; and is adjusted to the focus of the lens by turning the nut d.

For minute dissection of animal or other tissues, which is generally performed under water, as hereafter described, the

Fig. 5.
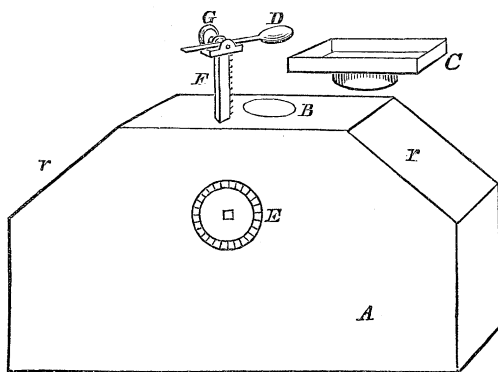
microscope of Mr. Slack, with the improvements of Dr. H. Goadby, F.L.S., is the most efficient. The following is a description of the instrument employed by the latter gentleman in his microscopic researches; and with which he has made a

great number of beautiful preparations in minute anatomy, entomology, &c. It consists of a box or case, which is represented by A, Fig. 5. The upper surfaces r, r, are sloped off to form arm-rests. The front of the case (which is not seen in the cut) is furnished with a flap or door, which has hinges at the bottom and a lock at the top; so that the various parts of the instrument may be packed up inside.

In the top of the box is a round hole, B, into which fits the short piece of tube attached to the tin box, C, which is designed to hold the water in which the dissection is made. The ring, D, is the lens-holder, which is adjusted to the proper focus by means of the milled head, E, which moves the rack, F, up and down, working inside the box A. The lens-holder has also a horizontal motion, by means of the rack and pinion, G. Another horizontal motion is produced by a swivel joint attached to F. Inside the box is a mirror, directly under the hole B, so that the light can be directed upwards through any transparent object at B.

When moderate power only is needed, a simple microscope is the best instrument which can be used; and for the purpose of making minute dissections it is also the most convenient; but when a very high magnifying power is needed, combined with distinctness of observation, a single (or simple) microscope is found to be imperfect: although very small lenses have been made, which magnify exceedingly—quite enough for all useful purposes. Good lenses, of a high magnifying power, may be made by drawing out a very narrow strip of glass in the flame of a spirit lamp, and upon the end of the thread thus formed, running a small globule by means of the flame, which may be detached from its thread and placed between two thin plates of metal in which a small hole has been drilled.

Optical Improvements in the Simple Microscope.—There are imperfections of vision attending the use of all common lenses; arising either from the shape of the lens, or from the nature of light itself when passing through a refracting medium. These imperfections are termed respectively, spherical and chromatic aberrations. To lessen or destroy these aberrations various plans have been proposed, with various success. Mr. Coddington proposed a lens in the form of a sphere, cut away round the centre, as at A, Fig. 6. This is an excellent form for a hand lens, but is not often to be procured in this country; opticians preferring to dispose of the

Fig. 6.
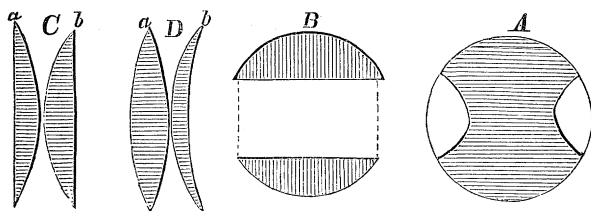
Stanhope lens, seen at B, which is more easily made than the Coddington lens, but is inferior to it. C and D are doublets proposed by Sir John Herschell; the first of which consists of two plano-convex lenses, *a, b,* whose focal lengths are as 2·3 to 1, with their convex sides together; the least convex next the eye, D, consists of a double convex lens, *a,* next the eye, and a meniscus, *b.* When these lenses are used for forming images the lenses marked *a* should be next the object.

Other forms of doublets have been proposed, but by far the

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best arrangement of this kind is *Dr. Wollaston's Doublet,*
which consists of two plano-convex lenses, whose focal lengths
are as 1 to 3 ; the plane sides of each, and the smallest lens,
placed towards the object. The lenses are set in separate cells
so as to adjust their proper distance apart, which is best done
by experimenting on their performance, although their dis-
tance is about the difference of their focal lengths. Between
them is a diaphragm or stop, generally placed immediately

Fig. 7.
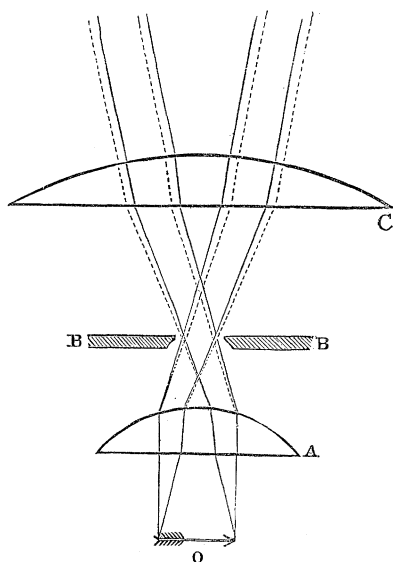
behind the anterior lens. The stop was not employed by Dr.
Wollaston, as his lenses were of such high power that they

nearly touched each other; yet it is, nevertheless, found to be essential to a good doublet.

A, C, Fig. 7, represent the lenses of the doublet, and B is the diaphragm or stop. The manner in which the light is refracted by this instrument, is shown by the lines proceeding from each end of the object, O. The dotted lines represent the blue or most refrangible rays of the spectrum; the others are the red rays. Those rays which pass through the centre of the lens, A, are caused to pass through the hole in the diaphragm over to the margin of B, and those nearest the margin of A pass next the centre of B; and so become nearly corrected : the imperfection of one being made to counteract that of the other.

An improvement was made upon this by Mr. Holland, and is called *Holland's Triplet*. It consists of a doublet in place of the first lens, A, in the last figure; retaining the stop between it and the lens C. This form is the highest stage of perfection which the simple microscope has ever yet attained. The great objection to its use, however, is, that it must be brought into such close proximity to the object, that it is impossible to cover such object except with the thinnest mica, which is objectionable on account of its liability to be scratched.

Before dismissing the subject of single microscopes, it may be well to remark, that for a low magnifying power, a double convex lens is the best to use; but for medium or high powers, a plano-convex lens, with the convex side towards the object; or one of the doublets just described; is preferable.

THE COMPOUND MICROSCOPE

Consists essentially of two convex lenses; an object-glass and an eye-glass; as represented in Fig. 8.

A is the object-glass, which forms a magnified image of the object at C, which is further enlarged by the eye-glass B. An

Fig. 8.
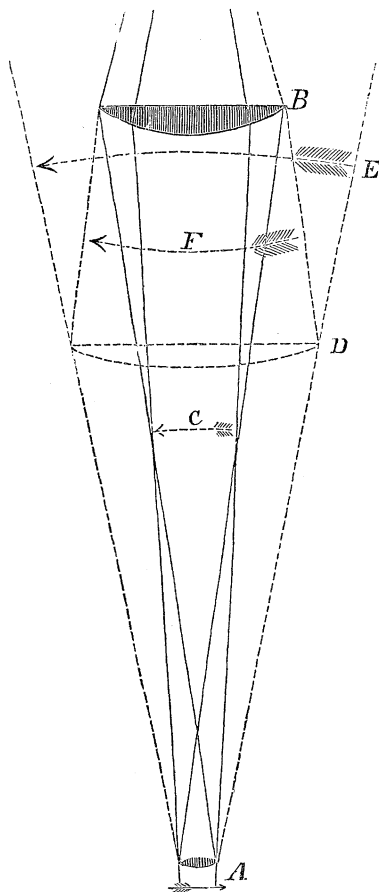
additional lens, D, is usually added; for the purpose of en-

larging the field of view. It is called the field-lens. An
inspection of the dotted lines in the figure will show that many
of the rays pass beyond the reach of the eye-glass, B : an
image from these rays is represented at E.   These rays are
intercepted by the field-glass D, and form an image at F, which
is viewed by the eye-glass.

In looking through a common microscope of this kind, the
observer will probably see rings of colour round the edge of
the field of view, and also similar colours around the edges of
the object he is viewing. These defects arise from the decom-
position of common white light; and are called chromatic
aberration or dispersion.   The colours round the field of view
are produced by the defects of the eye-piece; and those round
the object, by the object-glass.   Again : if the object be
looked at through the instrument as before, its outline or
edges will be observed, not sharp and distinct, but thick and
confused.   This is caused by the rays not being collected into
a perfect point as they were on the object itself.   This defect
is called spherical aberration.   When an instrument has
neither its chromatic nor spherical aberration removed, it is
said to be uncorrected.

To conceal these defects there is generally a small hole or
stop behind the object-glass.   This is injurious to correct
vision, as it prevents a large portion of light from entering the
eye, and makes the objects appear dark, so that their true
structure cannot be made out.   When this is the case, the
instrument is said to want angular aperture.   The stop refer-
red to, however, is essential even to the moderate performance
of a common instrument.

To obviate all these difficulties, improvements have been made
both in the object-glasses and the eye-pieces.   Wollaston's
Doublet has been found capable, when used as an object-glass
with the Huygenian eye-piece (hereafter described), of trans-

mitting a large pencil of light with great distinctness, having
an angular aperture of from 35° to 50°. Mr. Holland's
Triplet, used in the same way, is capable of transmitting a
pencil of 65° with distinctness and correctness of definition.
The achromatic object-glasses, as first proposed by Mr. Lister,
have however superseded all other attempts to improve the
compound microscope, and have raised it from the condition of
a mere toy, to be the most valuable instrument of scientific
research.   They are made of plano-concave flint, and double-
convex crown glass lenses, cemented together.   Three com-
pound lenses form the object-glass for a microscope, as repre-
sented by Fig. 9, *a, b, c.*   In object-glasses of a high power,

Fig. 9.
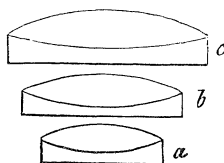
the anterior compound lens, *a,* has sometimes an adjustment to
render it suitable for objects either uncovered or covered with
glass of various thickness.   The object-glass, thus made, is not
quite achromatic, being rather over-corrected as to colour, but
is finally corrected by using the Huygenian eye-piece, shown in
Fig. 10.
   This eye-piece consists of two plano-convex lenses, A, B, with
their plane sides next the eye.   In the focus of A is the dia-
phragm or stop, C.   The proportions of the focal lengths of
these lenses should be as 3 to 1, and their distance apart, one-
half the sum of their focal distances.   Thus, if B be three

inches focus, A should be one inch, and their distance apart two inches.

Fig. 10.
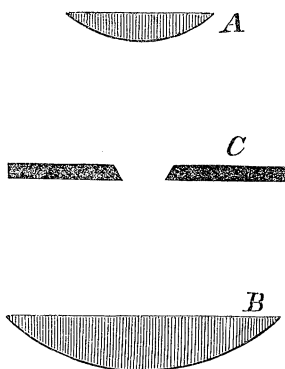
Sometimes, when a very flat field of view is required, as in the use of a micrometer eye-piece, the convex sides of the lenses face each other. It is recommended that for this kind of eye-piece the lenses should be nearly of the same focal length, and at a distance equal to two-thirds the focal length of either.

A good compound microscope should be furnished with many mechanical conveniences, in addition to the optical part just described. It should be capable of being steady in any position from vertical to horizontal—have coarse and fine adjustments for focus—have a large and firm stage, with ledge, clips, &c.; and with traversing motions, so as to follow an object quickly, or readily bring it into the field of view,—and should have a concave and plane mirror, of two inches diameter, with a universal joint, and capable of being brought nearer or farther from the stage, as likewise of reflecting a side-light.

A variety of forms have been given to the mechanism of the

compound microscope, many of which are very good, while
others are exceedingly objectionable.   Suffice it to say respect-
ing them, that steadiness, or freedom from vibration, and
particularly freedom from any vibrations which are not equally
communicated to the object under examination and to the
lenses by which it is viewed, is a point of the utmost conse-
quence.   A microscope body containing the lenses, screwed by
its lower extremity to a horizontal arm, is the worst form con-
ceivable.

The most celebrated artists in the manufacture of these
instruments are Powell and Lealand; Ross; and Smith and
Beck, of London.   A microscope from the latter firm is repre-
sented in the frontispiece.

The body slides by a rack and pinion, moved by the milled-
head, a, on a strong dovetailed bar; and has also a slow mo-
tion for delicate adjustment of focus, given by the milled-head
b. It is furnished with a sliding tube, c, for varying its length;
and with three sliding Huygenian eye-pieces, d, d', d'', of
successive powers.

The erecting glasses, y, are to be screwed, when employed,
into the other end of the sliding tube.   They rectify the
image, which is inverted when seen in the usual way.   Their
chief advantage is in microscopic dissection.

The stage has two steady rackwork motions, at right angles
to each other and to the axis of the body, given by the milled-
heads, e, e'; it has also a sliding and revolving plane, f, with
a ledge, g, for resting object-slips upon, and a sliding-piece, h,
with springs for clamping them.   An upright rod, i, is fixed
on this plane for mounting the forceps, v, or for the spring-
holder, j, when a glass trough, u, is used.   A profile of the
glass trough, with its diagonal plate of glass for confining an
object, is seen at u'.   At z, is a three-pronged forceps.

A large double mirror, k, concave on one side and plane on

the other, is supported by the cylindrical bar, *l*, and may be moved upon it vertically and sideways.

A movable diaphragm, *m*, is fixed under the stage for varying the quantity and direction of the light when transparent objects are viewed. The illuminating lens, *n*, is used for condensing light upon opaque objects; and a silver side-reflector is for the same purpose. The bull's-eye lens, for increasing the illumination, is seen at *r*.

An achromatic condenser, *x*, slides into the place of the diaphragm, to give the utmost refinement to the illumination of transparent objects.

The live-box, *s*, is for observing living objects between two glass plates; and a second live-box, *s'*, with screw collar, for objects in water. The screw is for regulating the depth of water, and the degree of pressure employed.

A plate of glass, *t*, with a ledge, has a separate piece of thin glass to lie upon it, for viewing animalcules, &c., in water.

The camera lucida, *w*, has its prism fixed on a short tube with a slight side motion for adjustment, and fits on each eyepiece when its cap is removed.

The three Lieberkuhns, *o*, *o'*, *o''*, adapted to the objectglasses 2, 3, and 4, are applied by sliding them in front of each respectively. When one of these is used, the diaphragm is to be removed, and the dovetailed piece, *p*, may be slid in its place, with one of the three dark wells or stops, *p*, *p'*, *p''*, which will make a dark background. If the objects are mounted on circular discs, *g*, the well will not be needed.

The object-glasses comprise four powers. No. 3 and No. 4 have the tube of their front lens movable for adjusting their performance with objects either uncovered or covered with thin glass. The graduated screw collar, by which the adjustment is made, is seen at 5.

The high price of these instruments must necessarily put

them out of the reach of those whose means are limited, and
our opticians seldom import them, except to order.   Of late,
however, a praiseworthy effort has been made to simplify the
construction of the mechanical parts, so as to bring the price
within the control of the generality of medical men and other
students of nature.   Mr. J. B. Dancer, Manchester, England,
furnishes a very complete microscope, with two object-glasses
and the necessary apparatus, for £10.   Messrs. Powell and
Lealand have also fitted up an instrument with a stand of cast-
iron, whose cost, exclusive of the object-glasses, is £9.   Other
manufacturers are also pursuing the same course.

From the cause above referred to, the majority of micro-
scopes used in this country are of French or German manufac-
ture.   Chevalier and Oberhauser have furnished some excellent
instruments; but the construction of most of those used or
exposed for sale, is far inferior to the English.   Hitherto, also,
the fashion in this country in regard to microscopes, has led
to the almost universal employment of high powers, to the
neglect of the others, so that it is exceedingly difficult to pro-
cure an achromatic object-glass with shallow magnifiers, not-
withstanding the decided advantage to be derived from their
use.

REFLECTING MICROSCOPES,

In which the image was formed by a concave mirror instead
of a lens, are not now so much used as formerly.   They are
generally complicated in structure, and are surpassed and
therefore superseded by the achromatic microscope.

The following is a simple reflecting microscope, invented by
Mr. S. Gray, and may be of some interest from its singularity.

A, Fig. 11, represents a brass ring, one-thirtieth of an inch
thick, whose inner diameter is about two-fifths of an inch.

Having dissolved a globule of quicksilver in one part nitric acid and ten parts water, he rubbed with it the inner surface

Fig. 11.
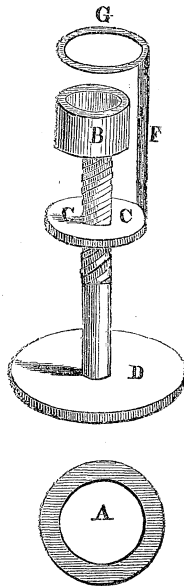
of the ring, which became silvered; having wiped it dry, he put a drop of quicksilver within it, which, when pressed with the finger, adhered to the ring, and formed a convex speculum. When the ring was taken up carefully, and laid on the margin of the cylinder, B, the mercury sank down, and formed a concave reflecting speculum. The cylinder, B, is supported by a pillar, which is attached to the foot, D. The stage, G, is for holding the object, and is adjusted to the focus by the screw at C.

CHAPTER III.

ADJUNCTS TO THE MICROSCOPE.

In addition to the mirror, object-glasses, eye-glasses, and the parts constituting the stand of a microscope, several accessory instruments are needed by those who would devote attention to microscopic researches. The most necessary or useful of these we proceed to describe.

The Diaphragm, for cutting off extraneous light when

Fig. 12.
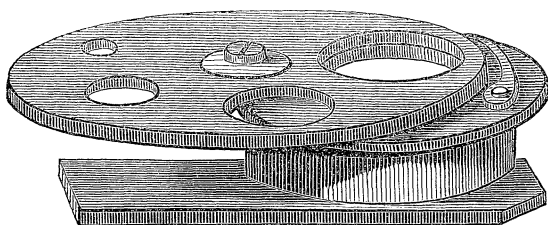
viewing minute transparent objects, consists of a plate of brass perforated with several holes of different sizes. This revolves on a pivot, so as to bring each hole in succession under the object-glass. It is adapted under the stage of the instrument, and is so essential in practice that few microscopes are made without it.

The Condenser.—This is an arrangement under the stage

for condensing the light upon the object. The best instruments employ an arrangement of achromatic glasses, similar to the object-glasses, but its value is scarcely equal to its cost. The Wollaston Condenser is a short tube, in which a plano-convex lens of three-fourths of an inch focal length, with its flat side towards the object, is made to slide up and down. Dr. Wollaston employed a long tube with a stop between the lens and the mirror, but Dr. Goring found it better to have the stop between the lens and the object, and a little out of the axis of the lens.

A substitute for the achromatic condenser is found in Mr. Varley's dark chamber. This is sometimes preferable to the Wollaston Condenser, as the light is not decomposed by passing through a lens.

c, Fig. 13, is a plate of brass adapted to the stage, in which is a short tube having a diaphragm or stop, a, whose aperture

Fig. 13.
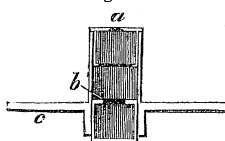
is equal to what can be viewed by the microscope and no larger. Below is a sliding tube, b, with an aperture rather larger than that at a. This last can be moved up and down until the light at a is of the greatest intensity. The aperture at a is always in proportion to the object-glass employed.

Polarizing Apparatus, (Fig. 14,) for viewing objects by polarized light. It consists usually of two prisms of calcareous spar, in proper tubes ; one below the stage, and the other in the eye-piece. Sometimes a thin piece of tourmaline is used in place of the prism in the eye-piece.

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Erector.—This is sometimes supplied with the best instru-
ments.   It consists of a pair of lenses acting like the erecting
eye-piece of the telescope.   It is applied to the draw tube at

Fig. 14.
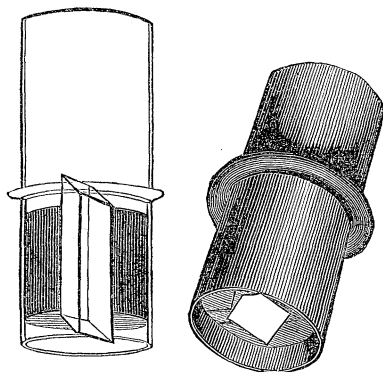
the end of the eye-piece towards the object-glass.   It is only
used when it is desired to dissect with the compound micro-
scope, as, without it, the position of the object appears re-
versed.

Condensing Lens and Lamp.—The Wollaston Condenser,
&c., is designed to concentrate the light which comes from the
mirror, directly upon the object; but the condensing lens and
lamp is used either for opaque objects, or to condense the light
upon the mirror itself.   Two such lenses, as in the figure, are
generally used.   Dr. Goadby informed me, that after many
experiments he has found a bull's-eye lens, of three inches
focal length, the most efficient for the larger lens; and after
several trials with different sorts of lenses I am disposed to
agree with him.   Fig. 15 illustrates one mode of using the
condensers upon opaque objects.   A, is the bull's-eye lens,

which turns upon its axis, and slides up and down a stout wire
affixed to a steady foot.   B, is the smaller lens, whose handle

Fig. 15.
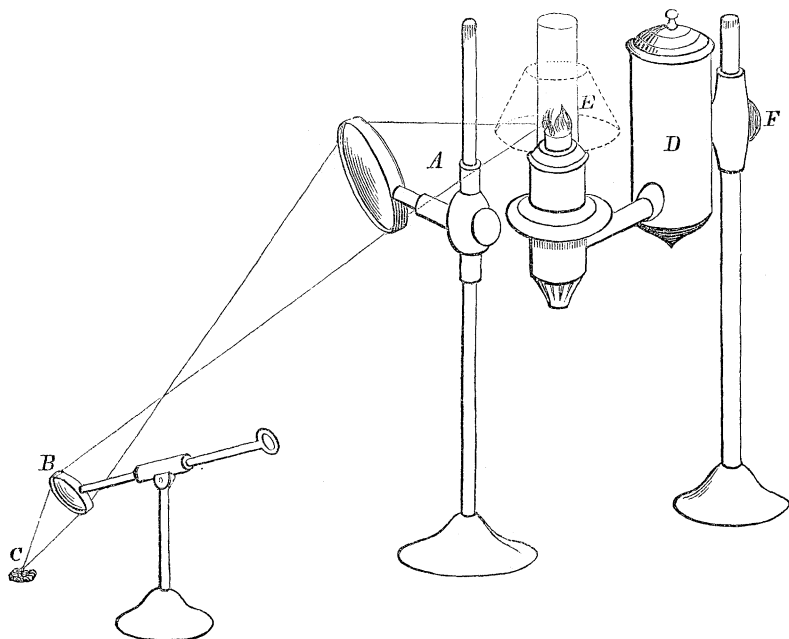
slides through a socket, working on a hinge joint.   Sometimes
a lens of this kind is affixed to the stage of the microscope.
C, is the object upon which the light is concentrated.   D, the
lamp. To condense the light on the mirror, the lens, A, alone
is used.   The lamp is of the kind called a fountain lamp, and
slides up and down a stem, on which it can be fixed at any
height by the screw F.   E represents a section of a shade,
which should always be used with the lamp.   As it is a matter

of much consequence to our observations that we should have a steady, intense light, it is not immaterial what kind of oil, &c., we employ. After many trials and disappointments, I am convinced that pure sperm oil is the pleasantest, cheapest, and best.

Lieberkuhn, or Silver Cup.—This is a most useful instrument for viewing opaque objects. It is attached to the object-glass in the manner represented by Fig. 16, where a is the lower end of the body of the microscope, b the object-glass,

Fig. 16.
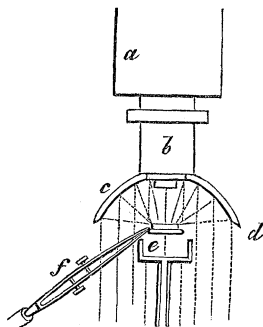
to which the Lieberkuhn, c, is attached. The rays of light reflected from the mirror, are brought into a focus upon an object, d, mounted in the usual way upon glass, or held in the forceps, f. When the object is transparent, or is too small to fill up the entire field of view, the dark well or stop, e, is used. This is generally fixed into the centre of the stage, a little below the upper surface. Sometimes, instead of a Lieberkuhn, a side-reflector is used, and from the greater obliquity of its reflection, is of great advantage in exhibiting delicate structures.

It has hitherto been considered impracticable to use very high powers with opaque objects, but the Athenæum informs us that "at one of Lord Rosse's recent scientific soirees, Mr. Brooke showed his new method of viewing opaque objects under the highest powers of the microscope (the $\frac{1}{8}$th and $\frac{1}{12}$th inch object-glasses). This is performed by two reflections. The rays from a lamp, rendered parallel by a condensing lens, are received on an elliptic reflector, the end of which is cut off a little beyond the focus; the rays of light converging from this surface are reflected down on the object by a plain mirror attached to the object-glass, and on a level with the outer surface. By these means the structure of the scale of the podura, and the different characters of the inner and outer surfaces, are rendered distinctly visible." I have not had an opportunity of testing this plan, but have little doubt of its success.

Camera Lucida.—By which drawings are made from the microscope. This is generally formed by placing a small prism of glass, inclined at the proper angle, in front of the eye-piece. In Fig. 17, *a*, represents the camera, formed of highly-polished

Fig. 17.
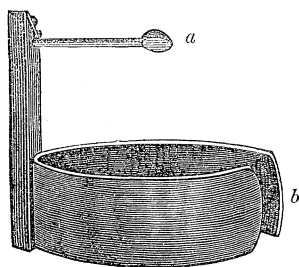
steel, smaller than the pupil of the eye, inclined at an angle of 45°, and fixed to a clip, *b*, which embraces the eye-piece.

Frog-plate; Fig. 18; on which frogs or fish are tied to ex-
amine the circulation of blood in their vessels.   The frog, &c.,

Fig. 18.
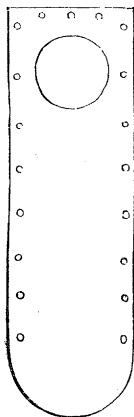
must first be enclosed in a bag, and fastened on the plate by
the holes in either side of it.   Then thread is tied to about
four of its toes, and the web is spread out over the large hole
by fastening the ends of the thread through the smaller holes
in the plate.

The Stage Micrometer consists of a slip of glass, pearl, &c.,
having a line finely divided into parts of an inch, &c.   To
obtain with this the power of a compound microscope, compare
the divisions seen with one eye through the instrument, with
a rule held ten inches off, and looked at with the other eye.
Suppose, for instance, the micrometer be divided into $\frac{1}{100}$ths
of an inch, and one of these divisions covers an inch of the
rule seen with the other eye, the magnifying power of the
instrument is 100 diameters.   If it should cover five inches,

it is magnified 500 diameters. By sketching the object by means of the camera, and then putting in its place a stage

Fig. 19.

A   B   C   D

Fig. 20.
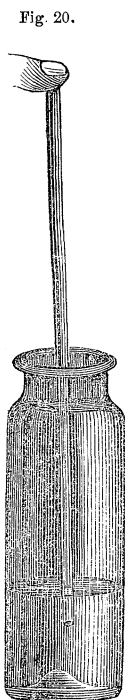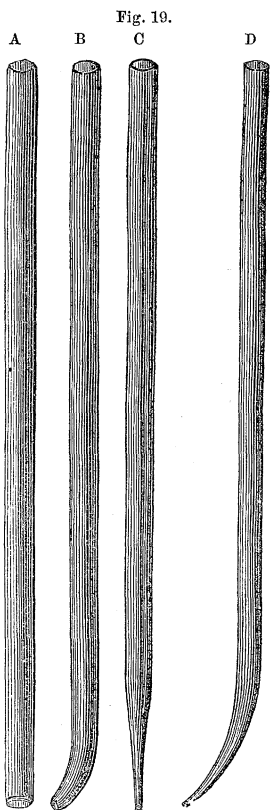
micrometer, and marking the divisions over the sketch, they can again be subdivided, and so the measure of an object be accurately taken.

Animalculæ Cage is a round cell with a glass bottom and top, for confining a drop of water with animalculæ.

Watch-Glasses and *Fishing Tubes,* are useful adjuncts. The latter, Fig. 19, are glass tubes of various sizes, by which when one end is closed with the finger a quantity of water, &c., may be lifted from a phial, as seen at Fig. 20, and put in a watch-glass. By their aid, too, with a little practice, an animalcula may be caught in a phial, when it is visible to the naked eye. With the finger on one end of the tube, approach the other end to the place where the animal is, then suddenly lifting off the finger, the current will carry it into the tube.

A Compressorium, for applying pressure to an object; a *trough* for chara and polypi; a *phial-holder,* &c.; will also be found useful.

CHAPTER IV.

HOW TO USE THE MICROSCOPE.

MANY persons imagine that the value of a microscope is in proportion to the apparent size of an object seen through it. This, however, is a mistake. The greater the magnifying power of an instrument, all other things being equal, the greater is the difficulty of finding a minute object on the stage, and of adjusting the focus. The light, too, transmitted from the mirror, becomes less intense, and the view less satisfactory with the use of high powers. For the majority of objects, a low or medium power is always preferable, on account of the greater extent of the field of view. The test objects, however, and the minute structure of any delicate tissue, &c., require very considerable amplification in order to exhibit them satisfactorily. When this is the case, the increase of power should be given by the employment of an object-glass of shorter focal length, in preference to the use of a more powerful eye-piece.

Sir David Brewster gives the following rules for microscopic observations.

1. The eye should be protected from all extraneous light, and should not receive any of the light which proceeds from the illuminating centre, excepting what is transmitted through or reflected from the object.—This rule will illustrate the use of the diaphragm under the stage of the microscope.

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50 THE MICROSCOPIST.

2. Delicate observations should not be made when the fluid which lubricates the cornea of the eye is in a viscid state.

3. The best position for microscopic observations is when the observer is lying horizontally on his back. This arises from the perfect stability of the head, and from the equality of the lubricating film of fluid which covers the cornea. The worst of all positions is that in which we look downwards vertically. The most common and easy position is generally with the instrument inclined at an angle of 45 degrees.

4. If we stand straight up and look horizontally, parallel markings or lines will be seen most perfectly when their direction is vertical; viz., the direction in which the lubricating fluid descends over the cornea.

5. Every part of the object should be excluded, except that which is under immediate observation.

6. The light which illuminates the object should have a very small diameter. In the day-time it should be a single hole in the window shutter of a darkened room, and at night an aperture placed before an Argand lamp.

7. In all cases, particularly when high powers are used, the natural diameter of the illuminating light should be diminished, and its intensity increased, by optical contrivances.

The following remarks by Mr. James Smith, copied from the Microscopic Journal, vol. i., are recommended to the consideration of all who are in the habit of using microscopes. "Much of the beauty of the objects seen depends upon the management of the light that is thrown upon or behind them; which can only be fully mastered by practice. It may be remarked, however, as a general rule, that in viewing those which are transparent, the plane mirror is most suitable for bright daylight; the concave for a lamp or candle, which should have the bull's-eye lens, when that is used, so close to it that the rays may fall nearly parallel on the mirror. If the

bull's-eye lens is not used, the illuminating body should not be more than five or six inches from the mirror. The latter is seldom required to be more than three inches from the object, the details of which are usually best shown when the rays from the mirror fall upon it before crossing, and the centre should (especially by lamp-light) be in the axis of the microscope. For obscure objects, seen by transmitted light, and for outline, a full central illumination is commonly best; but for seeing delicate lines, like those on the scales of insects, it should be made to fall obliquely, and in a direction at right angles to the lines to be viewed.

" The diaphragm is often of great use in modifying the light, and stopping such rays as would confuse the image (especially with low or moderate powers), but many cases occur when the effects desired are best produced by admitting the whole from the mirror.

" If an achromatic condenser is employed instead of the diaphragm, its axis should correspond with that of the body; and its glasses, when adjusted to their right place, should show the image of the source of artificial light, or, by day, that of a cloud or window bar in the field of the microscope, while the object to be viewed is in focus.

" The most pleasing light for objects in general, is that reflected from a white cloud on a sunny day; but an Argand's lamp or wax candle with the bull's-eye lens is a good substitute.

" A large proportion of opaque objects are seen perfectly well (especially by daylight) with the side reflector, and the dark box as a background; and for showing irregularities of surface, this lateral light is sometimes the best; but the more vertical illumination of the Lieberkuhn is usually preferable, the light thrown up to it from the mirror below being, with good management, susceptible of much command and variety."

The management of the light with opaque objects must depend in a great degree upon their size, and the manner in which they are mounted. If the object is small, and so mounted as not to intercept much of the light from the mirror, the mode illustrated by Fig. 16 is the best; in other cases, that shown in Fig. 15 is preferable.

Next to the proper illumination of the object, the adjustment of the focus is the most important thing to be attended to. With a low power, the coarse adjustment is usually sufficient if the workmanship be good; but with a high power it becomes necessary to resort to the more delicate arrangement of the fine adjustment. Great care must be taken, however, lest the glass on which the object is mounted be broken, or the object-glass injured, by too sudden or too close a contact.

CHAPTER V.

ON MOUNTING AND PRESERVING OBJECTS FOR EXAMINATION.

If a low power is used, and the object be one not necessary to be preserved, it can be well seen if placed in the forceps or on a slip of glass, but if it be desired to keep it for future examination, some method of preserving it from decay, dust, &c., must be resorted to; and the method will vary according to the nature of the object.

TRANSPARENT OBJECTS.

Transparent objects are mounted on slips of glass, the size of which, as adopted by the Microscopic Society of London, is 3 inches by 1 inch, or 3 inches by $1\frac{1}{2}$ inches. The French opticians, however, prepare many of their slides $2\frac{1}{4}$ inches by $\frac{5}{8}$ths of an inch, and this size is most frequently imported into the United States; indeed, a larger size is unsuitable for many of the French instruments, although to be preferred on other accounts.

There are three methods of mounting transparent objects. 1st, in the dry way—in which the object is simply placed upon the slip of glass, and covered with a thin glass cover, cemented by its edges to the under piece, with sealing-wax varnish, &c.

5*

2dly. In some preservative fluid.

3dly. In Canada balsam.

The glass slides should be clear, free from veins and bubbles, of uniform length and breadth, and should have their edges ground smooth by rubbing them on a flat cast-iron plate with emery and water.

Sections of teeth and bone, and of some kinds of wood, hairs of animals, scales of butterflies, test objects from the infusoria, &c., are best mounted dry; but all very delicate animal and vegetable tissues, to exhibit their structure clearly, should not be mounted in the dry way, nor in Canada balsam, but in some preservative fluid.

PRESERVING FLUIDS.—A very considerable number have been recommended by different observers. A mixture of salt and water was used by Dr. Cook for this purpose; there is an objection to it, however, owing to the development of a confervoid vegetable.

Mr. J. T. Cooper, some years since, made some experiments with a view to determine the best fluid for preserving vegetable coloured tissues, such as some of the smaller fungi, and found that salt and water, 5 grains to the ounce of water, to which acetic acid had been added, answered very well. A few drops of creosote or of camphor will prevent the growth of confervæ.

One part alcohol to 5 of distilled water—1 ounce to 4 of water—will preserve even very delicate colours. This is the basis of the Gannal process for preserving animal structures. There is, however, the same objection to the use of this fluid as to the salt and water.

A weak solution of chromic acid is a good preserving fluid.

Pure glycerine is prepared by the London opticians as a preservative fluid, and is used in the proportion of 1 part to 2 of water. Its oily nature, however, often causes much difficulty in cementing the thin glass cover upon it.

Dr. Goadby has devoted much attention to this subject, and has succeeded in supplying to the microscopist a ready, cheap, and effectual means for mounting animal structures with the greatest possible ease and security.   Dr. G. received a gold medal from the Society of Arts for his invention.   He has kindly furnished me with the following description of his different preserving fluids.

> " A 1.   Bay salt (coarse sea-salt), 4 ounces,
>   Alum, 2 ounces,
>   Corrosive sublimate, 2 grains,
>   Boiling water, 1 quart.
>
> " A 2.   Bay salt, 4 ounces,
>   Alum, 2 ounces,
>   Corrosive sublimate, 4 grains,
>   Boiling water, 2 quarts.

" The A 1 fluid is too strong for most purposes, and is only to be employed where great astringency is required to give form and support to delicate structures.

" The A 2 fluid may be very extensively used, and is best adapted for permanent preparations; but neither of these fluids should be used in the preservation of animals possessing any carbonate of lime (all the Mollusca), as the alum becomes decomposed, and the sulphate of lime is formed and precipitated, and the animal spoiled.   For such use the

> " B. fluid. specific gravity 1·100.
>
>   Bay salt, 8 ounces,
>   Corrosive sublimate, 2 grains,
>   Water, 1 quart.

" Marine animals require a stronger fluid of this kind, viz., specific gravity 1·148, which is made by adding more salt (about 2 ounces) to the above.

" The corrosive sublimate is used to prevent vegetation grow-

ing in the fluid, and no greater quantity should be used than
2 grains per quart of fluid; but, as it coagulates albumen, it
must be left out when ova are to be preserved, or when it is
desired to maintain the transparency of certain tissues."

A paragraph has recently been published in the newspapers,
to the effect, that "a couple of French *savans* have simulta-
neously discovered that chloroform is an antiseptic of marvel-
lous virtue, preventing animal decomposition after death, or
promptly checking it if already commenced. All animal
tissues when subjected to its action become fixed for a long
period of time in the precise form and condition in which they
may happen to be at the moment of application, and natural
colours, even to the slightest and most delicate shades, are
preserved without the slightest change." If this be so, the
desideratum in this respect will be supplied. I have not had
an opportunity of testing it, but look upon it as quite pro-
bable.*

* Since the above was written, the following extract, confirming
the alleged discovery, appeared in the Medical Examiner:—"M.
Augend has communicated to the French Academy of Sciences the
following experiments, which establish a marked line of demarcation
between ether and chloroform, and point out in the latter a remark-
able property which has hitherto escaped the attention of chemists.

"If three wide-mouthed, ground-stoppered bottles are taken, and
into one we put a few drops of ether, into another a few drops of
chloroform, and leave the third in *statu quo;* then place in each a
piece of beef, secure the stoppers, and leave them during summer
weather, the following phenomena are observed:—The flesh, natural-
ly of a reddish-brown colour, passes at once to a vermilion-red, under
the influence of the vapour of chloroform mixed with air, whilst it
undergoes no change in the ether. Such are the immediate effects,
but at the end of a week the results are still more distinct. The
flesh preserved in the air has changed its colour slightly, that which
is preserved in the ether has become brown, whilst that in the chlo-
roform has acquired the appearance of boiled meat. On opening the
bottles, the meat in the air has become offensively putrid, and the

MOUNTING IN FLUID.—The most minute structures, such as the vessels of plants, and the muscular and other tissues of animals, requiring in all cases high powers for their proper exhibition, must of necessity be preserved in very thin cells with a small amount of fluid.

On a slip of glass, 3 inches by 1, cleaned by a solution of caustic potash to remove all grease, lay a drop of the fluid; put the object in this and spread it out with the point of a needle, &c. Select a thin and flat glass cover, clear it likewise from grease, &c., touch its edges with cement, and drop it gently over the object. Press it lightly, to exclude the excess of fluid, which can be removed by strips of blotting-paper. Then cement the edges of the cover to the bottom glass. Care must be taken to exclude all air-bubbles from between the glasses. Objects mounted thus do not keep long, and it is

same thing occurs in the presence of the ether, whilst there is no change in the flesh kept in the chloroform, apart from the sweet taste and peculiar odour of the latter.

" These antiseptic properties of chloroform have furnished interesting results to M. Augend. He has found that 1·2000th part of it (?) suffices to preserve a mass of muscular flesh. Not less remarkable is the facility with which the vapour permeates the densest tissues. Chloroform has this advantage over creosote, that it does not coagulate the albumen ; nor is it on its part decomposed by muscular fibre.

" The most apparent action of the chloroform, not only on muscular substance, but also on the fleshy pericarps of fruits and seeds, is an immediate contraction of the fibre or the parenchyma, which causes the watery juices to flow out on the bottom of the vessel in which the experiment is made.—*Gazette Médicale*."

From the foregoing account, it would seem proper to expose many delicate tissues to the vapour of the chloroform before mounting in balsam; or they may be preserved in the chloroform itself, although it would be difficult, in such case, to find a proper cement for the glass cover.

best to make a thicker cell. This may be made by painting a round or square ring on the slip with some sort of cement which will not be acted upon by the fluid employed.—White lead worked with 1 part linseed oil and 3 of spirits of turpentine is well adapted for this purpose.—In this ring, the fluid and object are placed and the cover put on.

Pieces are also cut off the ends of glass tubes and cemented on the slips with marine glue, so as to form very neat cells. A square piece of glass, with a hole drilled in it, cemented on the slip, forms an excellent cell. Such cells, ready prepared, are imported and kept by McAllister & Co., Chestnut Street above Second, Philadelphia; together with slips, thin glass for covers, mounted preparations, a good variety of instruments themselves, and other things interesting or useful to the microscopist.

Pieces of gutta percha tubes, cemented on to the slips by heat, may sometimes be used for cells, and answer a good purpose. I have made excellent cells by using narrow slips of glass for the sides, cementing them with marine glue. They are square, and are well suited for the larger class of objects.

CEMENTS.

Japanners' Gold-size, or Severe Dryer, is a mixture of boiled linseed oil, dry red lead, litharge, copperas, gum animi, and turpentine. The first and last ingredients are its principal constituents. Mr. Williams, Artists' Furnishing Store, Sixth Street above Market, Philadelphia, has it for sale.

Sealing-wax Varnish consists of small pieces of sealing-wax dissolved in alcohol.

Asphaltum, dissolved in turpentine, has this advantage, that spirit may be employed as the preserving fluid if desired.

Marine Glue is a mixture of shell-lac, caoutchouc, and naph-

tha.   It is melted by heat.   Caustic potash will remove its traces from glass.

Gum Mastich and Caoutchouc, dissolved in chloroform, is an excellent cement, and has the advantage of remaining fluid at ordinary temperatures, while the rapid evaporation of the chloroform enables the slide to be quickly prepared.

A solution of Canada balsam in ether or turpentine, evaporated to such a consistence that it can be laid on with a camel's-hair pencil, may be used like the last described, as a substitute for marine glue.

Lampblack and white hard varnish, when laid on immediately, is a good cement.   Sealing-wax and white lead have also been recommended.

For the thin glass covers, a mixture of the gum mastich cement, above described, with asphaltum dissolved in turpentine, will be found very suitable.

MOUNTING IN BALSAM.

Before objects are mounted in Canada balsam they should be perfectly clean and free from moisture.   They are commonly soaked in turpentine, especially opaque objects, as it renders them more transparent.   Grease may be removed by sulphuric ether.

Very thin and transparent objects become indistinct in balsam ; they should be made dark.   Vegetable matters may be charred between two plates of glass over a lamp.   Other structures which cannot be charred, may be dyed by soaking in a decoction of fustic or logwood, or a weak tincture of iodine.

The balsam should be warmed on the slide to expel the air. When objects of a cellular nature have to be mounted, if they are such as heat will not much injure, they may be boiled in the

balsam ; otherwise numbers of air-bubbles will be left in the
cells, and the true structure cannot then be made out satisfac-
torily.   The extra degree of heat will expand the air and
cause it to escape, and the balsam will take its place.

Some objects of a tubular nature, such as the tracheæ of
insects, are better seen if air be contained in the tubes ; they
will then exhibit the spiral fibre in their interior; but a tra-
cheal tube filled with balsam does not show the fibre at all, the
balsam having made all the parts transparent.   Small insects,
such as fleas, and the parasites of animals, when not over-
heated, show the ramifications of the trachea, but those which
have been soaked long in turpentine, or have had the air ex-
pelled by heat, do not exhibit the spiral markings except under
polarized light.

When air is to be got rid of, the heat must be high ; other-
wise, the use of turpentine must be avoided, the heat of the
balsam kept low, and the mounting accomplished quickly.

The best way to heat the balsam on the slide is to place the
slide on a flat piece of iron, over a spirit-lamp; yet with careful
management a spirit-lamp will do alone.

Some persons keep their balsam in a tin vessel that can be
warmed so as to melt it.   A drop of the fluid can then be
taken out and put on the object upon the slide.   This plan is
attended with little or no risk of air-bubbles.   The cover
should be warmed on its under surface before it is laid on
the balsam, and if necessary, a small amount of heat applied
to the under side of the slide, to make the balsam flow more
readily.

When animal structures, such as parts of insects, or injec-
tions, have to be mounted, the heating of the balsam must be
carefully managed, and the balsam itself be very fluid to com-
mence with.   It should be sufficiently warmed to expel all air-
bubbles, and, when nearly cold, the object should be placed

in it and covered in the usual way.   By pursuing this plan
(for which, with many other suggestions, I am indebted to
Mr. Quekett's admirable work on the Microscope), I have suc-
ceeded in making some excellent preparations at the expense of
but little time and trouble.

If the heat applied to the slide be great, the object will be
sure to curl up, and bubbles will appear in all parts.   It will
most likely be rendered useless, as no manipulation, however
carefully applied, will restore an overheated specimen of ani-
mal structure to its former beauty.

MOUNTING IN THE DRY WAY.

For objects which require a high magnifying power, they
may be placed on a slide and covered with thin glass, whose
edges may be touched with cement.   Objects which do not
require an object-glass of short focus, may be placed between
two slips of glass whose edges have been levelled so as to form
a groove, which may be filled up with cement or sealing-wax.

MOUNTING OPAQUE OBJECTS.

These must necessarily be viewed by light reflected in some
manner from their surface.   Some transparent objects, however,
may be viewed as opaque ones by using the dark well or stop,
e, Fig. 16.   When mounted with this design they may be
placed on the slip of glass with a little gum-water, and sur-
rounded with a rim of card, paper, &c., sufficiently thick to
form a proper cell, which may be covered with thin glass.
Sometimes opaque objects are fixed on a round piece of black
paper stuck upon a slide.

a, Fig. 21, represents a disc of leather, felt, or other suitable
material, about three-eighths or half an inch in diameter, with a

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pin passing through it.   The side for holding the object is to be blackened;   the other   side is   covered   with   white   paper   on

Fig. 21.
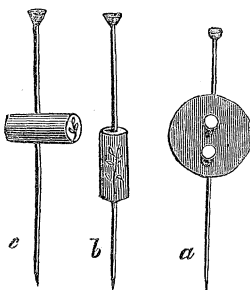
which the name is written.   *b* represents another plan, for very minute objects; the pin is encased with blackened wax or cement, or passes lengthwise through a small cork cylinder.

Fig. 22.
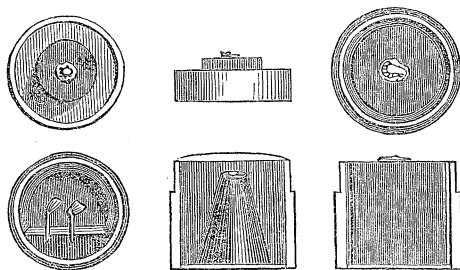
Another method is seen at *c*, which consists of a small cylinder of cork or felt with a pin passing transversely.   These must be blackened with common lacquer (shell-lac dissolved in alco-

hol) and lampblack, holding them over a candle to dry.
Sometimes these cylinders are made of ivory, with the inside
turned hollow like a small box; the pin runs through them as
at c, and supports the object. The ivory is dyed black and
the inner surface made as sombre as possible. Mr. Quekett
recommends to place the objects on pieces of cork glued to the
bottom, side, or cover, of small pill-boxes, as seen in Fig. 22.
Opaque objects should always be viewed with a black ground,
and the darker the object, the more sombre must be the
mounting. White is, of all colours, the worst which can be
employed, unless the object is totally black.

MOUNTING CRYSTALS FOR POLARIZED LIGHT.

These must be so enclosed that the air is completely ex-
cluded, otherwise a change will take place, and the objects be
spoiled. When it can conveniently be done, it is well to
mount them in Canada balsam. Sir David Brewster recom-
mends mixing cold-drawn castor oil with the Canada balsam.
In this case the edges of the thin glass cover should be ce-
mented, as the castor oil prevents the balsam from becoming
hard.

Each preparation should be properly labelled, either with a
writing diamond on the glass slide, or on the paper cover of the
slide; and it may save trouble if this be invariably performed
as soon as mounted.

CHAPTER VI.

THE topic suggested by the title of this chapter is almost endless; for the microscopist may claim contributions from every department of natural science. The animal, vegetable, and mineral kingdoms, all offer him interesting objects of investigation. We shall content ourselves with noticing some of the most important or attractive in each department.

INORGANIC.

Agate.—This form of silica is often found imperfectly crystallized, and thin plates, prepared by the lapidary's wheel, $\frac{1}{50}$th of an inch thick, exhibit a rich motley colouring when viewed by polarized light.

Carbonate of Lime.—Small spherules of this substance are sometimes found in the urinary deposits of the horse. They are often composed of concentric layers; at other times the fibres are radial. Illuminated by polarized light under a power of 100 diameters, they are splendid objects.

Crystallization of Salts.—Independently of the beautiful forms assumed by different salts during their crystallization, a great variety of forms may be obtained by mixing small quantities of the different solutions in a little weak gelatine, starch, mucus, &c. To procure specimens, put a drop or two of water,

solution of gelatine, &c., upon a slide, put into it a drop of some strong solution of salts, as Epsom salts, hydrochlorate of ammonia, tartaric acid, &c. Hold the slide over the spirit-lamp until evaporation is perceived, when it should be removed and placed under the microscope. If the evaporation is too rapid, the crystals will not be well formed. They may be mounted dry, or in balsam. A power of 30 diameters is generally sufficient. Crystals of salts form interesting and splendid objects under polarized light.

Ice.—A plan for observing the crystallization of water is as follows. Mix some water with a little charcoal, chalk, &c., in such manner that a number of fine particles may be mechanically suspended in it; then take a glass slide, place it on a cold night in an exposed situation, as outside of a window-sill; pour upon it as much water as it will support without running over the edge, and let it remain all night. The next morning, if the weather has been sufficiently cold, and the atmosphere dry, neither water nor ice will be seen on the slide; but the particles of charcoal will be found arranged in the various forms which they assumed while the water crystallized. The slide may be carefully prepared with Canada balsam for preservation.

Crystals of Iron Pyrites, and other substances; *Oolites;* and various sorts of *sand;* are interesting objects. The sand from Turkey sponge, and from the sea, often contains minute shells of various kinds, as the *foraminifera*, &c., corallines, and other zoophytes.

Sections of Granite, Limestone, &c., are also of considerable interest; but *sections of coal,* made very thin, so as to be viewed by transmitted light, develope clearly its vegetable origin, and are therefore of special importance.

Deut-Ioduret of Mercury.—The change of colour in this salt is a beautiful object. If a little of it be placed in a watch-

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glass, having another inverted over it, and then the lower one heated over the flame of a spirit-lamp, the salt will be sublimed. Placed on the stage of the microscope, with a power of 30 diameters adjusted to focus at the inner surface of the upper glass, minute crystals will be seen to form of a bright yellow colour, which, as they cool, return to the original red.

VEGETABLE TISSUES.

Vegetable Tissues are prepared by tearing, making thin sections, maceration in water, dissection, or are examined in their natural state.

The spiral, dotted, and reticular vessels of plants require generally to be dissected out, which is to be done under a shallow magnifier. A single lens of one inch focus will answer very well for this purpose. Having procured a piece of asparagus, or the petiole of the garden rhubarb, &c., cut out a piece about an inch long; split it open with a sharp knife or scalpel, examine it under the magnifier, and separate with a needle-point any of the vessels you require from the surrounding cellular tissue. This process is facilitated by dropping a little water on the specimen. To prevent it moving, the specimen may be fixed with beeswax during the dissection. Vessels, ducts, and cellular tissue, when prepared, should be kept in spirits of wine until mounted.

Cuticles.—The external covering of plants, or cuticle, consists of a thin membrane, adherent to the cellular tissue beneath it. Under the microscope it appears traversed by lines in various directions, giving its surface a reticulated appearance. The form of these reticulations varies in different plants: in some they are hexagonal, in others prismatic or

irregular.   Cuticles may be mounted dry or in fluid.   The
geranium, oleander, &c., afford good specimens.

The cuticle of the under side of the leaf of many plants,
exhibits under the microscope dark spots among their reticu-
lations.   These are called stomata, and are the orifices by
which a function analogous to respiration in animals is effected.
They also serve for the exit of water from the plant by means
of evaporation.   Plants destitute of stomata, as the South
American Cacti, &c., will remain in a hot and dry atmosphere
without losing their moisture.   The form, number, and ar-
rangement of the stomata vary in different plants.

Cellular Tissue is the first and most generally developed
simple form of vegetable life.   Its primary development may
be seen by examining a small portion of yeast at intervals
under the microscope.   No plant is without cellular tissue,
and many are destitute of any other kind of tissue, as the
lichens, and some fresh-water algæ.   A section of the pith of
elder, pulp of peach, &c., will afford specimens.

The petals of flowers are mostly composed of cellular tis-
sue; their brilliant colours arise from the fluid contained with-
in the cellules.   These form excellent microscopic objects, and
when mounted in balsam are permanent.   The pelargoniums
and geraniums are among the most interesting.

The petal of the anagallis, or scarlet chickweed, is a beauti-
ful object.   The spiral vessels diverging from the base, and
the singular little cellules which fringe the edge, are worthy
of notice.

Vascular Tissue, prepared by maceration and dissection,
presents many interesting subjects.   Spiral vessels consist of
membranous tubes with conical extremities, internally fur-
nished with one or more spiral fibres.   As the vessels grow,
the spiral fibre breaks into short pieces, forming rings.   The
vessels are then called annular.   If the pieces of fibre are still

shorter they are called dotted or reticulated vessels.   The root
of the garden rhubarb, the stem of the hyacinth, the leek, &c.,
furnish examples.

A peculiar form of vessel is met with in the common car-
rot; it is obtained from the root in a layer between the yellow
central portion and the red annulus.

Sections of Wood.—These are cut thin, so as to allow them
to be viewed as transparent objects.   Hard woods, containing
gum, resin, &c., should be soaked in essential oil, alcohol,
ether, &c., before mounting.   By transverse slices, a variety
of beautiful lace-like objects may be obtained, but little infor-
mation is acquired from them of the real structure of the wood.
For this purpose, if the tree is of the endogenous and branch-
less kind—which grow by additions to the interior—a vertical
section is also necessary.   If the tree be an exogen, two verti-
cal sections will be required in addition to a transverse one.
The exogens grow by annual layers exteriorly under the bark,
and are branched.   In these one of the vertical sections should
be radial and the other tangental.   The radial vertical section
will show the number and size of the medullary rays; that is,
the small portions of pith which proceed horizontally from the
centre, enclosed in a sheath of woody fibres.   The frequency
and size of the medullary rays determine the number and
strength of the branches of the tree.   This section also ex-
hibits in coniferous trees (as the pine, &c.), the beautiful disc-
like glands which adhere to the woody fibres.   These are
beautiful objects, and sometimes require a power of 200 or 300
diameters.   The tangental vertical section is a slice across the
medullary rays; it exhibits the form and arrangement of the
cellular tissue within them.   All the vertical sections show the
form, size, and connexion of the woody fibres; spiral, reticu-
lated, and dotted vessels, &c.; and are far more instructive than
the transverse sections.

Charcoal.—Thin sections of charred wood are very interesting and instructive.

Fossil Woods.—Thin sections must be made by grinding on a lapidary's wheel. They should be polished.

Siliceous Cuticles, &c., from equisetum, straw, cane, &c., are prepared by heat in a covered crucible, or by boiling and digestion in nitric acid. The most favourable example for showing the form in which silica occurs in plants, is the husk of the oat or wheat. If a husk of oat be examined under the microscope, having been mounted in water or Canada balsam, a series of bright parallel columns, serrated on each side, may be observed among the cellular tissue : if another specimen be burned carefully between the glasses, and the ashes be mounted in balsam, the siliceous columns will still be seen. In the ashes of the husk of wheat, rows of concave discs may be observed, which are composed of some metallic oxide. In the ashes of the calyx and pollen of the mallow, organized lime may be detected. In the ashes of coal, a variety of vegetable structures, as cellular tissue, spiral vessels, &c., may be discovered. In these experiments it is necessary to render the ashes transparent by immersion in balsam.

Hairs, Down, &c., from leaves and stems, are generally opaque objects. In the plants which produce cotton, the hairs are attached to and envelope the seeds. Hairs are composed of cellular tissue. Their functions are said to be either lymphatic or secreting. They offer great varieties in form, some being stellated, others forked or branching.

Pollen may be mounted in Canada balsam; or, if rather transparent, in fluid; or dry. Sometimes the grains are interesting opaque objects. The common form of the pollen or farina of flowers is spherical, with a smooth, punctured, or spiny surface; but some are square, others cylindrical, oval with attenuated extremities, or triangular with convex sides. The pollen of the passion flower is very curious, and if immersed

in very diluted sulphuric acid opens and disperses the grains. The pollen of *Datura stramonium*, or Jamestown weed, and others, when immersed in a few drops of weak acid placed upon a slide under the microscope, emits a tube of some length.   The granular matter in the pollen may then be seen to pass along the tube until the pollen is emptied. The diameter of the pollen varies considerably in different plants; among the smallest are those of the Sensitive Plant.

Starch.—The granules of starch (not the ordinary impure starch of the laundress) obtained from different plants, are found, when examined under the microscope, to differ in size and form.   Some are spherical, others elliptical, flask-shaped, polyhedral, &c.   Hence this method of examination affords a ready means of detecting fraud in the substitution of one kind of grain for another.   Starch granules, although so very minute, are composed of a fine and delicate membrane, enclosing a fine mealy powder.   It may be compared in some respects to a common pea, in which the legumen is enclosed in a testa or skin.   Starch granules are not soluble in cold water, nor is iodine capable of acting on them while the membrane enclosing its contents remains whole. If the granules be triturated or immersed in hot water, the membrane will be ruptured, and iodine will then turn them blue.   Starch is readily separated from wheat, potato, arrow-root, &c., by repeated washings in cold water.   To obtain it from rice, the grains should be macerated for a few days, and to prevent the decomposition of the gluten, a little soda should be added to the macerating water.   Under the microscope, the surface of starch-grains often appears corrugated, and each of them has one or two bright spots, called the hilum, which is supposed to be the part where the starch adheres to the cell.   Under polarized light they present the beautiful phenomenon of the black cross.   They should be mounted dry, and protected from the pressure of the upper glass by a rim of thin paper.

Seeds are generally opaque objects, and present a great variety of beautiful and interesting forms.

Hard Tissues, the stones and shells of nuts, &c., are prepared like bone, &c., by cutting and grinding. Some require the lapidary's wheel.

Raphides, or crystals from the interior of plants. If the leaf or bulb of a common hyacinth be wounded, a discharge of fluid ensues; if this be received on a slide and submitted to the microscope, a number of minute acicular bodies will be observed floating in the liquid. They are called raphides. They are common in many plants. By scraping hickory, or other bark, on to a slide, moistening it with the breath, and blowing off the woody particles; or by placing a part of the ashes of a burnt maple leaf, coat of an onion, &c., on a slide, such crystals may be seen. They may be mounted dry or in balsam.

Mosses, are supposed to be destitute of woody fibre and vascular tissue. When a leaf is carefully examined, the septa which divide the cells are sometimes found to take a spiral course. To observe this structure, soak the moss in water, to expand the cells.

It is essential, in collecting mosses, to preserve the theca or seed-vessel, for without it the genera cannot be determined; while this part, with the calyptra and operculum, are the most valuable for the microscope.

Algæ.—Are interesting objects. The green, mucous, slime-like matter in damp garden walks, and the hair-like weeds in ditches, are examples of fresh-water algæ. The sea-weeds of our coast are marine algæ, and are often found having zoophytes adhering to them; they are then splendid opaque objects. For mounting in balsam, the smaller kinds, of a bright scarlet colour, are the most valuable.

Ferns.—The genera are mainly distinguished by the position and arrangement of the organs of reproduction. These

are mostly on the under side, or along the margin of the leaf or frond. They are best examined as opaque objects. They should be collected before they are quite ripe. The spores (seeds) are usually enclosed in brown capsules, each having an elastic ring about its equator, which when ripe bursts, and the spores are dispersed to a distance. Spores may be mounted either as transparent or opaque objects. The development of ferns may be observed by placing the spores in moistened flannel and keeping it at a warm temperature. At first a single cellule is produced, then a second, and so on. After this the first cellule divides into two, and then the others, by which a lateral increase takes place.

Lichens and Fungi afford interesting objects. The various kinds of mildew upon vegetable substances are familiar examples of minute fungi.

Organic Fabrics possess much interest in a commercial point of view, in addition to the curiosity arising from the manner in which the threads or bundles of fibres are woven or interlaced. For this purpose they should be examined as opaque objects on a black ground, with a magnifying power of from 30 to 60 diameters. The fibres of cotton are readily distinguished under the microscope from those of linen, wool, &c. Cotton fibres are tubular, and are formed of pure cellular tissue. These tubes, from the thinness of their sides, often collapse and appear like flat ribbons or bands. The reason assigned for the preference given to linen (flax) over cotton for lint, for surgical purposes, is that the fibres of the former are solid cylinders of woody fibre, while the edges of the flattened bands of the latter are supposed to irritate the wounds.

Circulation in Vegetables.—The circulation in plants, termed *cyclosis*, is a revolution of the fluid contained in each cellule, and is distinct from those surrounding it. It can be observed in all plants in which the circulating fluid contains particles of

a different refractive power or intensity, and the cellules are of sufficient size and transparency. Hence all lactescent plants, or those having a milky juice, with the other conditions, exhibit this phenomenon. The following aquatic plants are generally transparent enough to show the circulation in every part of them : — *Nitella hyalina, Nitella translucens, Chara vulgaris,* and *Caulinia fragilis.* In the Frogbit (Hydrocharis), it is best seen in the scales surrounding the leaf-buds, with a power between 60 and 200 diameters.

The jointed hairs of the filament of the anther in *Trandescantia virginica* (Spiderwort); the delicate hairs on the leaf-stalk of *Senecio vulgaris* (Groundsel); and a section of the leaf of *Vallisneria spiralis,* will show the circulation, especially when viewed with a high power.

ANIMAL TISSUES, ETC.

INFUSORIA. — These minute animals, some of which are only the $\frac{1}{25000}$th part of an inch in diameter, are extremely numerous. Between 700 and 800 different species have been discovered and described. Dr. Ehrenberg, to whom we are indebted for much of our knowledge respecting the animalculæ, divides them into two classes, i. e., Polygastrica and Rotatoria. The first class is so named from their possessing a digestive apparatus composed of many globular vesicles, which perform the functions of stomachs. The Rotatoria are so called from their possessing rotary organs about their mouth. These are much more highly organized than the others. The Polygastrica increase by self-division, or by the growth of gemmules or buds upon their bodies ; the Rotatoria are hermaphrodite, and oviparous. Many animalculæ are loricated ; or protected by a shell, or shield, which is generally siliceous : others are destitute of such an appendage.

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The following table exhibits the families or groups into which this interesting department of animal life has been divided by Ehrenberg. Those who wish further information respecting them are referred to his work "Die Infusionsthierchen," or to Pritchard's "History of Infusoria, Living and Fossil." Dr. Mantell's work on Animalcules contains also much valuable information.

CLASS I. POLYGASTRICA.

Anentera, or without true alimentary canal.	Body destitute of appendages. (No foot-like processes.) *Gymnica.*	Form of body constant.	Self-division complete.	illoricated or shell-less,	Monadina.
				loricated or shelled,	Cryptomonadina.
			self-division incomplete, hence formed in clusters.	self-dividing on all sides (globular),	Volvocina.
				self-dividing unilaterally (filiform). illoricated,	Vibriona.
				loricated,	Closterina.
		Form of body variable.	illoricated,		Astasiaea.
			loricated,		Dinobryina.
	Foot-like processes variable. *Pseudo-poda.*		illoricated,		Amoebaea.
			loricated,	compound foot-like process from one aperture,	Arcellina.
				simple foot-like process from one or from each aperture,	Bacillaria.
	Hairy *Epitricha.*		illoricated,		Cyclinida.
			loricated,		Peridinaea.
Enterodela—with an alimentary canal.	One receiving and discharging orifice only for nutrition. *Anopisthia.*		illoricated,		Vorticellina.
			loricated,		Ophrydina.
	Two ditto orifices, one at each extremity. *Enantritena.*		illoricated,		Enchelia.
			loricated,		Colepina.
	Orifices situated oblique. *Allotreta.*		illoricated,	mouth furnished with proboscis, tail absent,	Trachelina.
				mouth anterior, tail present,	Ophryocercina.
			loricated,		Aspidiscina.
	Orifices abdominal. *Catotreta.*		illoricated,	locomotive organs cilii,	Kolpodea.
				do. do. various,	Oxytrichina.
			loricated,		Euplota.

CLASS II. ROTATORIA.

With a simple continuous wreath of cilii. (*Monotrocha.*)	margin of cilii-wreath entire. *Holotrocha.*	{ illoricated, Icthydina. loricated, Oecistina.
	margin of cilii-wreath lobed or notched. *Schizotrocha.*	{ illoricated, Megalotrochaea. loricated, Floscularia.
With a compound or divided wreath of cilii. (*Sorotrocha.*)	with the cilii-wreath divided into several series. *Polytrocha.*	{ illoricated, Hydatinea. loricated, Euchlanidota.
	with the cilii-wreath divided into two series. *Zygotrocha.*	{ illoricated, Philodinaea. loricated, Brachionaea.

In reference to obtaining infusoria, some persons imagine that if they procure a portion of fetid ditch-water, or take a few flowers, &c., and macerate them in water, they will be furnished in a few days with all the varieties they may desire ; but this is not the case. Infusoria will of course be found, but they will be only of the most ordinary kinds. To obtain those of higher interest, some degree of skill is required. Many remarkable species have been taken in meadow-trenches in the slowly running water, after a summer shower, especially about the time that the first crop of hay was mown. Among healthy water-plants, the various kinds of Vorticellina (*Stentors* and *Vorticellæ*, or trumpet and bell-shaped infusoria), and Rotatoria (wheel-animalcules), may be sought for with success. The stems of aquatic plants have often the appearance, to the naked eye, of being encased with mouldiness, or *mucor*, which on being examined with the microscope, proves to be an extensive colony of arborescent animalcules. The dust-like stratum sometimes seen on the surface of ponds, and the shining film which sometimes covers water-plants, assuming various hues of red, brown, yellow, green, and blue, is caused by the presence of infusoria, some of which are very beautiful. Many species live in the clean fresh water of rivers, lakes, and springs ; and the brine of the ocean, likewise, as well as the

mould on the surface of the earth, has its microscopic inhabitants.

In order to procure animalculæ, provide yourself with a number of clean, wide-mouthed, glass phials, fitted with proper corks, not glass stoppers, so that the air may have access to them, at least to some extent. Have also a rod, or walking-cane, which may be prepared with a spring-hook and ferule for fastening a phial on its end, although a piece of twine is a good substitute. On reaching the pond, &c., carry the phial (attached to the rod) in an inverted position, and when at proper depth, or in the neighbourhood of water-plants, it should be turned quickly, when animalculæ, &c., will run into it. Water-fleas and Daphniæ should be frightened away by shaking the phial before turning. If in the phial, they go quickly to the bottom, and the upper water can be poured off. Examine the water with a pocket lens, and preserve the animalculæ.

The indications of the presence of infusoria are specks moving about in the water, or an apparent mouldiness around the stalks of the water-plants, &c., which may have been caught in the phial. If these appearances be not discerned by the magnifier, the water may be thrown away, and another place resorted to. A small portion only of vegetable matter should be preserved in the phial, as its decay may soon kill the animalcules.

Small newts and many larvæ should be preserved; the former especially, as they eat up the Daphniæ, Monoculi, &c., that destroy the Vorticellæ. In the branchiæ of young newts, too, and in their feet, the circulation of the blood is beautifully seen.

The phial should sometimes be laid horizontally on the bottom of the pond, and scrape the surface of the mud. This should be put in a large jar with water, and in a day or two

the animalculæ will be on the surface of the mud, from which they can be removed with the fishing-tubes (see page 47), and placed under the microscope.

If the creatures are too minute to be seen easily with the naked eye, pour a little water from the vessel containing them into a watch-glass, and place it on a piece of card-board, rendered half black and half white. The white ground will make the dark specimens apparent, and vice versa. They can then be seen with the pocket lens, and taken out with the fishing-tubes.

In order to show the stomachs, cilia, &c., of animalculæ under the microscope, rub some pure sap-green or carmine on a palette or plate of glass, and add a few drops of water. If the glass be now held on one side, a portion of the colouring matter may be put into the water on the slide containing the animalculæ. If they be vorticellæ or rotiferæ, the particles of colouring matter will show the vibratile actions of the cilia, whilst other particles, swallowed by the animals, will give a rich tint to the compartments of their alimentary canal.

Fossil Infusoria.—A great number of infusorial earths may be mounted in balsam (test objects dry, however,) without washing, &c., but others must be repeatedly washed or digested in acid. For the skeletons or shields in carbonate of lime, Professor Ehrenberg has directed to place a drop of water on the slide, and put into it as much scraped chalk as will cover the fine point of a knife, spreading it out, and leaving it to rest a few seconds; then withdraw the finest particles, which are suspended in the water, together with most of the water, and let the remainder become perfectly dry. Cover this with Canada balsam, and hold it over a lamp until it becomes slightly fluid, without froth.

Siliceous Shields of Infusoria, such as those in guano, Richmond earth, &c., require to be well washed, and boiled or

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digested in nitric or hydrochloric acid. After this, a small quantity of the sediment in which they are contained should be placed on a number of slides, and those containing the best specimens laid aside for mounting.

Sponges.—These lowly-organized bodies are found both in salt and fresh water in all parts of the globe. Many of them are very minute, and may be examined without much preparation, but others require to be burned, or acted on by acid, to show the small masses of flint, called spicula, which form their rudimentary skeleton, as well as other masses of the same material, which enter largely into the framework of the young sponges or gemmules.

Corals are best examined by horizontal and vertical sections. If the animal matter only is required, the sections may be macerated in hydrochloric acid, to which five or six times its bulk of water has been added.

Zoophytes.—Residents at the sea-side, or occasional visitors, when provided with a microscope, have frequent opportunities of examining some of these most elegant of animal forms. Scarcely a piece of sea-weed or fragment of shell will be found, that does not afford a habitation for some member of this interesting family. The animals are generally found in clusters, or compound, sometimes communicating at a common centre; at other times distinct and only connected by the solid matter of which their polypidoms are formed. Some few, as the common fresh-water polype, do not secrete any hard substance either around or within them.

INSECTS.—These afford the most numerous and beautiful objects for examination, as there is scarcely a part of the body of an insect that does not exhibit some remarkable structure.

Antennæ.—The horns of insects not only vary in form in different genera, but in the male and female of the same species. They may be mounted as opaque, or in Canada balsam.

Eggs.—The eggs of insects are generally of an oval form, the outer covering being sufficiently rigid to resist ordinary external impressions; others are, however, soft and pliant. In some species they are globose, as in many Lepidoptera; or conical, as in the large white cabbage-butterfly; cylindrical, pear-shaped, barrel-shaped, &c. They are for the most part smooth; but many are very beautiful, ornamented with symmetrical ridges, canals, dots, &c., giving them, as Reaumer observed, the appearance of embossed buttons. Some are furnished with appendages for peculiar purposes. Thus the eggs of the dung-fly (*Scatophaga putris*) has two oblique props at one end, to prevent it sinking too deep in the matter upon which it is deposited, while those of the water-scorpion (*Nepa cinerea*) are furnished with a coronet of spines, forming a receptacle for the egg which is deposited immediately afterwards. Sometimes, one end of the egg is provided with a sort of cap or lid; at other times the egg is in one piece, and the enclosed larva must gnaw or burst through it. The colour is very various, although white, yellow, and green are the most prevalent tints.

In many species the eggs are deposited singly; in others, they are discharged *en masse.* Some arrange them symmetrically, and others enclose them in a mass of gluten, especially those whose larvæ inhabit the water. Many species employ a gummy matter to attach them firmly to the substances on which they are placed; while some, as the yellow-tail moth (*Arctia chrysorrhœa*), wrap them in a coating of down, which they pull off their own bodies; and the lackey moth (*Lasiocampa Neustria*), deposits her eggs in a spiral coil round the stems of fruit trees.

Most varieties require to be viewed as opaque objects under a power of 30 to 60 diameters.

Elytra, or wing-cases of insects, are often singularly engraved and coloured, and form the most brilliant of all opaque

objects. Some are covered with beautiful iridescent scales, and others are furnished with branched hairs. Some of them are much improved by being mounted in a thick cell with Canada balsam, while others lose much of their splendour by being so treated. In order to ascertain whether an elytron will be improved by the balsam, one of the legs, or some part supplied with a few of the iridescent scales, should be touched with turpentine; if the brilliancy be increased, it may be mounted in balsam, if otherwise, dry. The elytra of some beetles, after having been softened in caustic potash, may be mounted between flat glasses, as ordinary objects.

Eyes of Insects, Arachnida, &c.—The structure, number, and form of the eyes of insects may be ranked among the most curious parts of natural history. They are generally hemispherical, on each side of the head, but sometimes they are oval or kidney-shaped. When closely examined, they are found to consist of a vast number of minute lenses, generally hexagonal, but sometimes quadrangular or circular. In the ant there are 50 of such lenses in each eye; in the common house-fly 4000; in the dragon-fly 12,500; and, according to Geoffroy, in the eye of a butterfly 34,650. When one of the eyes is detached from the head and cleaned, the lenses are found to be as clear as crystal. If a cluster of eyes be placed under the microscope, at a distance without its focus equal to their focal length, the lens of each eye will exhibit a distinct image of a candle, &c., placed before it.

The external form of the eye may be seen in situ in all insects when viewed as opaque objects, but the layer of lenses requires the aid of maceration and dissection to free them from a considerable amount of pigment. They may then be mounted dry, in fluid, or in balsam. If required to be flat, they must be made so by pressure while soft, otherwise they are liable to split.

If the eye of a fly, or other insect, properly prepared by mounting in balsam, be held near the eye of an observer who looks through it at a distant candle, &c., the interference of light in the minute lenses will cause a number of images to be perceived, tinged with beautiful colours.

The eyes of spiders are single. They have from four to twelve, variously arranged. Some insects have also single eyes in addition to the compound eyes before noticed.

Feet.—The structure of the feet of those insects which support themselves on polished surfaces, and against the force or gravity, is very remarkable, and it is doubtful if it be yet perfectly understood. Some suppose them to act as suction-pads, others that they secrete a viscid fluid by means of which they stick with sufficient force to enable them to walk. The latter theory is rendered most probable by microscopic researches.

The number of pads on each foot is variable.

The anterior and middle pairs of feet of the male Dytiscus are furnished with curious disc or cup-shaped appendages on the inside of the leg. They may be viewed as opaque and in balsam.

Hairs of Insects, &c., may be mounted dry, in fluid, or in balsam. In some spiders the hairs are branched; in the larvæ of many insects they are covered with spines, as the hairs of caterpillars, &c.; and in the crustacea they are provided with spines, or plumed like a feather. The hairs and scales of insects will be further treated of in the chapter on Test Objects.

Heads, Mouths, &c.—The manducatory apparatus of insects is a subject of great interest to the entomologist. The division of insects into Mandibulata and Haustellata are founded thereon; the first having jaws, the latter a proboscis or sucking instrument. Some of them require but little preparation, and may be mounted as opaque objects; others, as the probosces and lancets of flies and bees, demand considerable skill

to display them to the best advantage.   When thin and trans-
parent, they should be mounted in fluid, but if thick and opaque,
in balsam.   Before mounting in the latter way, they should be
dissected while soft, and laid out on a slide to dry.

Parasitic Insects should be placed in spirit and water in
order to kill them.   They may be mounted in fluid or balsam.
Some of the large kinds may be examined as opaque objects.
The term Epizoa has been applied to them because occurring
on the exterior, in contradistinction to those occurring within
animals, which are called Entozoa.   Some of them are classed
with insects, as having six legs; while others, having eight, are
called Acari, and are included in the class Arachnida.

Some very minute insects, called Aphides, are abundant on
plants, the leaves, &c., of which they destroy.   Others, called
Cynips, are the cause of the excrescences on the leaves, &c.,
of trees, termed galls.   The well-known oak-apple is produced
by the *Cynips quercus*, which is a most elegant object when
examined by reflected light.   The same may also be said of
the insect from the gall of the rose.   Gather the galls when
ripe, and place them in a box covered with gauze.   In a few
days or weeks numbers of insects will escape from the gall,
and those exhibiting beautiful colours may be selected.

Among the Acari, may be mentioned the cheese-mite, *A.
domesticus*, and the itch-insect, *A. scabiei.*   To obtain the
latter, the operator must examine carefully the parts surround-
ing each pustule, and he will generally find in the early stage
of the disease, a red spot or line communicating with it; this
part, and not the pustule, must be probed, and the insect, if
present, be turned out.   It is often, however, difficult to de-
tect its haunts.

To obtain the *Entozoon folliculorum,* which is a parasite
occurring in the sebaceous follicles of the skin of the forehead,
nose, &c., squeeze the neighbourhood of the little black spot

or pustule, so as to force out the sebaceous or oily matter.
This should be laid on a slide, and a small quantity of oil
added to separate the insects from the nidus in which they are
imbedded. They may then be transferred by a pencil-brush
to a clean slide, covered with thin glass and mounted.

Another species of Acarus, the harvest-bug or tick, *A. au-
tumnalis*, is a very painful source of irritation to the skin
wherein they may have insinuated themselves. They may be
dislodged with a needle, and mounted in fluid or balsam.

Tracheæ and Spiracles of Insects.—The respiratory system
of insects will be described in the chapter on Dissections, to-
gether with their nervous, digestive, and circulatory systems.
The manner of mounting them is alluded to on page 60.

Stings, Ovipositors, &c., frequently require considerable care
in dissection. They may be mounted in fluid or balsam.

SHELLS OF MOLLUSCA.—The structure of shell has only
lately attracted the attention of microscopists, but since the
year 1842 the subject has been scientifically investigated by
Mr. Bowerbank and Dr. Carpenter. According to the experi-
ments of the latter gentleman, undertaken at the request and
expense of the British Association, the calcareous matter in
all shells is nearly equally crystalline in its aggregation, and
the particular forms which their fracture presents are deter-
mined chiefly, though not entirely, by the arrangement of the
animal basis of the shell, which possesses a more or less
highly-organized structure.

All thin sections of recent shell are translucent, except
when the colouring matter is opaque, or when the calcareous
matter is deposited in a chalky state between the true laminæ
of the shell, as in the oyster.

Dr. Carpenter classifies shells, into—1. Prismatic cellular
structure, as exemplified in the *Pinnæ*. 2. Membranous shell
substance, as the *Mya, Anatina*, and *Thracia*. 3. Nacreous

or pearl structure, as the inner surface of some species of *Ostrea* and *Mytilus*. 4. Tubular structure, as the outer layer of *Anomia Ephippium, Lima scabra*, &c. In some cases the tubes run.at a distance from each other obliquely through the shell, as in *Arca Noæ*. 5. Cancellated structure. Examples of this latter division, which somewhat resemble the cancelli of bone, are only met with in certain fossil shells.

Shell should be examined microscopically in three ways : by reflected, transmitted, and polarized light. For the first, fragments of shell will suffice ; for the others, thin sections, cut both vertically and transversely, are necessary. To exhibit the animal basis of shell, specimens may be treated in the manner recommended for coral.

SCALES OF FISH.—M. Agassiz has arranged the class of fishes into four orders, according to the structure of their covering, as follows :

Enamelled Scales.

1. *Placoïdians.* Cartilaginous fishes, having prickly or flattened spines, as the skates, dog-fish, and sharks.

2. *Ganoïdians.* With angular scales composed of horny or bony plates covered with enamel, as the sturgeon, and bony pike. Fifty out of sixty genera are extinct.

Scales not Enamelled.

3. *Ctenoïdians.* Scales notched or serrated on their posterior free edges, as the perch.

4. *Cycloïd* fishes, with smooth scales, more or less circular, and laminated, as the herring, salmon, &c.

Among the various kinds of fish-scales selected for microscopic objects, those of the eel are much prized, as it was formerly considered that it had no scales. They may be obtained

from the under surface of the skin with a knife or a pair of forceps.

Some scales when viewed by polarized light have a brilliant effect. They may be mounted in balsam. Fossil scales, as well as others, may be examined as opaque objects.

HAIR OF ANIMALS, &c.—Hairs are composed of an aggregation of epithelium cells, and the colour depends upon the quantity of pigment deposited in or about each cell. Care should be taken to select both the hair and the wool from each animal, as they differ materially in their structure ; the finer kind, or what is known as wool, being endued with the property termed *felting*, which property is of considerable importance in a manufacturing point of view.

The felting property is owing to the imbricated scales on the outside of each hair. In the adult human hair this structure is not very apparent, but may frequently be seen in fine specimens from very young infants. These, however, should not be mounted in balsam.

The smaller kind of hair may be mounted dry or in fluid ; or, if of a dark colour, in balsam. Horizontal and vertical sections should be made of large hairs and spines, which may be done after gluing a number together, in the same way that sections of wood, &c., are made.

Sections of horns, hoofs, quills, whalebone, spines of echini, &c., are all interesting objects.

ANATOMICAL OBJECTS AND PREPARATIONS.

BLOOD.—To examine this vital fluid, it is necessary to place upon a glass slide a small drop recently taken, and cover it with a thin glass or piece of mica. The blood corpuscles may also be preserved in Dr. Goadby's A 2 fluid, or prepared by

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drying rapidly on the slide and covering with the thinnest glass.

The red corpuscles in man are of a circular flattened form. If water be added to them, they become spherical by endosmose. Their appearance varies as they are viewed a little in or out of the focus of the microscope; in one place showing a nucleus or spot in the centre, and in the other a thickened edge, like a ring. In all air-breathing, oviparous, vertebrated animals, the blood corpuscles are oval, and a nucleus may be observed within each of them. This nucleus is rendered very distinct by the addition of a drop of diluted acetic acid.

The observations of Professor Owen on the blood-discs of the *Siren lacertina*, show that the nucleus consists of a cluster of nucleoli enclosed in a capsule in the centre of the oval blood-disc. The length of the disc in the Siren is $\frac{1}{450}$th of an inch, while the diameter of human blood-discs average $\frac{1}{3000}$th of an inch.

Circulation of Blood may be seen in the web of a frog's foot (see page 46); in the fin or tail of a fish; and in the legs, &c., of many spiders and insects, especially aquatic larvæ. There is nothing so wonderful and pleasing as the sight of the blood corpuscles coursing through the vessels in the web of a frog's foot, when seen with a power of about 200 diameters. The researches of Kaltenbrunner; a distinguished German pathologist; on the circulation of blood in a frog's foot, and the influence of various irritants upon it, as seen under the microscope; have added much to our knowledge respecting congestion and inflammation, and are of the highest interest to the practitioner and student of medicine. They are referred to by Dr. Watson in his preliminary lectures on the Practice of Medicine, and their importance clearly shown.

BONE should be cut into thin sections, about $\frac{1}{50}$th of an inch in thickness. They can be cut with a fine saw, such as

are made of watchspring. They should then be cemented on a piece of glass; filed to the proper thinness; ground upon a hone; and polished by a leather strap or piece of cloth charged with putty powder (oxide of tin and lead), or carbonate of iron (rouge). They may be mounted dry or in balsam. Both transverse and longitudinal sections should be made.

When animal tissues are consolidated by the deposition of earthy matter within their cells and fibres, a hard, solid substance is produced. Sometimes the earthy matter crystallizes, as in the teeth; at other times it combines chemically with the gelatine of the cells, as in bone. This deposition in bone does not occur in all the cells, as the bone requires to grow and be nourished; hence arises its peculiarity of structure. Independently of the hollows, or cancelli, the hard part of the bone is traversed by canals, called Haversian, which run in the direction of the laminæ; these are connected by transverse communications. In a thin transverse section of bone, the solid matter may be observed arranged around the Haversian canals in concentric rows. Among these layers dark specks are dispersed. These dark specks (called *lacunæ;* or *corpuscles of Purkinje*), when magnified about 200 diameters, are observed to be cavities of an irregular, oval form, from which emanate numerous minute branch canals. These cavities appear dark for the same reason as a minute air-bubble does in Canada balsam—namely, the difference of refraction of the two media. By means of these branches (*canaliculi*), lacunæ, and Haversian canals, the bone is nourished with proper fluids.

It has been shown by Mr. J. Quekett, that there are differences in the form and size of the lacunæ, in the various classes of animals, sufficiently characteristic to allow of the assignment of minute fragments of bone, with the aid of the microscope, to their proper class. The lacunæ of reptiles are distinguish-

able by their large size, and long oval form ; and those of fish, by their angular form and the fewness of their radiating canaliculi. The lacunæ of the bird may be distinguished from those of the mammal, partly by their smaller size, but chiefly by the remarkable tortuosity of their canaliculi. It is worthy of remark, also, that the sizes of the lacunæ in the four classes of vertebrata, bear a close relation to the sizes of their blood corpuscles.

SECTIONS OF TEETH may be made in the same way as bone. Some should be soaked in hydrochloric acid, to destroy the earthy matter, and others in caustic potash, to get rid of animal matter. These should be mounted in fluid, the others dry, or in balsam.

A tooth consists of three distinct structures, the relative proportions and arrangement of which constitute the chief differences in the teeth of various animals. 1. Enamel. This is crystallized phosphate of lime, deposited in the form of long prisms, each about $\frac{1}{3000}$th of an inch in diameter, produced in animal cells, which are almost obliterated when the tooth is fully formed. In human teeth a coating of enamel is formed over the crown of each. In the teeth of some animals the enamel is disposed in vertical layers among the other structures of the tooth. This is especially the case with the grinding teeth of large herbivorous animals. 2. Dentine, or Ivory. This forms the principal substance of which the teeth are composed. The amount of animal gelatine in it is often very considerable. The earthy matter is usually deposited in the form of fine branching cylindrical tubuli, radiating from the centre of the tooth. These tubules have been successfully injected with colouring matter by Dr. White, of Philadelphia. On the ends of the dentine tubuli are placed the ends of the enamel prisms, in the human tooth. Dentine is now established by Professor Owen as an ossification of the pulp of the tooth.

3. The Bone or Cementum, of teeth, is composed of a mass of earthy matter and cartilage, having minute cavities or bone corpuscles and calcigerous canals.

Sometimes a vertical section is made of a tooth *in situ*, exhibiting a section of the jaw with its cavities for the nerves and vessels, as also the manner in which the alveolar process which forms the socket is constructed. Both vertical and transverse sections should be made.

SKIN.—In some animals, as fish, the skin is not very vascular, while in the mammalia, and, perhaps, in the human subject, it attains the highest state of organization. The skin performs a function in the animal economy second only in importance to that of the lungs, and for the purpose is supplied with a very rich capillary network; and also provided with two or more sets of glands, one for secreting the perspiratory fluid, the other an unctuous or sebaceous matter for lubricating the skin itself. Taking the human skin as an example, we should commence the study with vertical sections, made through parts supplied both with hair and papillæ. The perspiratory glands are best seen in the soles of the feet, and palms of the hands; the sebaceous glands should be examined in parts about the face or chest, where hairs are numerous; these latter sections will also show the roots of the hairs and the hair follicles. The skin may be rendered firm enough for vertical section by hardening in a saturated solution of carbonate of potash or in strong nitric acid. The capillary network of the *cutis vera* may be seen in injected specimens when the cuticle has been removed, which will often require the aid of maceration for the purpose. If the skin be that of a black man, care should be taken in the removal of the cuticle, as in it may be examined the *rete mucosum*, or coloured layer, which consists of a series of minute hexagonal cells, containing pigment. The same structure may be seen in the skins of animals whose

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hairs are black; for this purpose the lips of a black kitten, when injected, should be selected, as in them the mode of growth of the young whiskers, their copious supply of blood-vessels and nerves, and various other points of interest, may be observed. The papillæ are best shown in the extremities of the fingers and toes, when injected; the cuticle which invests them should also be mounted as an object, with its attached or papillary surface uppermost, as in this the grooves for their lodgment, together with the openings of the sudoriferous glands, can be well seen.

EYES.—Many objects of interest may be obtained from the eyes of various animals; as the crystalline lens, the pigment, the ciliary processes, the retina, and the membrane of Jacob. The structure of the crystalline lens in fish is best seen after the lens itself has been hardened by drying, boiling, or long maceration in spirit. After having peeled off the outside, the more dense interior will be found to split up into concentric laminæ, and each lamina will also be found to be composed of an aggregation of toothed fibres; these are best seen when mounted in fluid, but if dyed, they will show very well in balsam. The pigment is easily obtained by opening a fresh eye under water. It may then be detached as a separate layer, and parts of it floated on slides to dry, after which they may be mounted in balsam. The ciliary processes are best seen when injected; they should be mounted in a convenient cell with fluid, and viewed as opaque objects. The retina should be examined from a very fresh eye, between glasses, and a little serum or aqueous humour added, to allow the parts to be well displayed; but water must be avoided, as the nervous matter will be considerably altered by it; the membrane of Jacob will also require the same precautions, but the vascular layer of the retina, when injected, may be well seen after having been dried.

MUSCULAR FIBRE.—Muscles are of two kinds, voluntary and involuntary; from their functions. The voluntary muscles of all the vertebrata, and the articulate animals (as insects, &c.), have their fibres marked with transverse striæ. The involuntary muscles are not so marked. These marks are supposed to point out the ultimate corpuscles or cells of which the fibrillæ are composed. The general opinion is, that the juxtaposition of cells is the true form of the ultimate fibre. Several microscopists, however, of some note, believe the fibre to be spiral, and enclosed in a membranous sheath. In my own examinations I have met with cases where the structure appeared to be a bead-like fibre wound spirally into a tube, or around a central unmarked fibre; yet other observations, especially with polarized light, show a longitudinal arrangement of cells. Perhaps the true structure is a compound of both these modes; the sheath being spiral, and the ultimate fibre longitudinal.

A small portion of muscle, freed from cellular tissue, may be put on a slide with some kind of fluid, placed under the dissecting microscope, and the fibres torn asunder with fine needles. It should be preserved in fluid under a thin glass cover.

The nerves of muscle may be displayed in a thin layer of delicate fibres which form a part of the abdominal wall of a frog, by employing a compressorium. The capillary blood-vessels may be seen when injected, in the thin recti muscles of the eyes of small birds. By the use of the compressor, these latter, if seen soon after death, will, without injection, show both nerves and capillaries.

NERVE.—The dissection of nerves, to show their ultimate structure, is similar to that of muscle, above described. It should be performed, however, in a little serum or white of an egg; as water, &c., changes its appearance. As soon as the true structure has been well seen; water, ether, &c., may be

added, to show how much they change its original appearance. In all examinations of nerve or muscle; the more delicate the structure, the sooner after death should it be dissected.

FIBROUS AND AREOLAR TISSUE.—Nearly allied to involuntary muscular fibre is a fibrous tissue termed the yellow or elastic; this is often found in connexion with another, finer and less elastic, and called from its colour, the white fibrous tissue; a mixture of the two is known to anatomists as the areolar tissue, and is largely used in the animal economy, as it forms a support for all the vessels, nerves, and muscles, from either of which it may be easily procured. The yellow tissue is found in nearly an isolated condition in the ligamentum nuchæ of the necks of some animals, especially of the ruminating tribe; it also enters largely into the formation of the intervertebral discs. A portion of the ligament from the neck of a sheep or calf, even after boiling, will exhibit the elastic fibres exceedingly well; they are of nearly uniform size, generally curled at their extremities, and of a yellowish colour. They may be prepared as muscle or nerve, with the needle points.

If any of the above tissues are to be kept they should be mounted in fluid, as spirit and water, or the creasote liquid.

MUCOUS MEMBRANE.—This is the investment of all the internal parts of the body, continuous with the skin. Every cavity, organ, or gland, which opens on the surface, is lined by it. Shut sacs are lined by serous membrane.

The mucous membrane may be divided into two parts: the epithelium, and the basement membrane. The external skin is evidently a similar structure, somewhat modified, and is capable, under certain circumstances, of taking on a similar function. The epithelium of skin is the cuticle or epidermis, but the basement membrane, though present, is not easily shown, except where the surface is raised into papillæ.

The epithelium exists in three varieties: the scaly, prismatic, and spheroidal. The first kind is most largely developed in the skin; the cuticle, with its horns, hairs, hoofs, and feathers, &c., is made up of it. Detached scales may be obtained from the inner side of the mouth, &c. The prismatic; or, according to Dr. Todd, the columnar; is abundant throughout the stomach and intestines, and even the lungs. Each prism is attached by its sides to its fellows, and endwise to the basement membrane. The attached extremity is generally pointed, the free one wide and flat, and covered with vibratile cilia, which may be often observed in rapid motion, some time after the death of the animal. The third variety, or spheroidal, is to be met with in all glandular structures, as the tubes of the stomach and kidney, and the secreting structure of the liver.

The basement membrane is structureless, and is not supplied in any way with vessels. The best places for viewing it are the tubes of the kidney and stomach, and the villi of the small intestines. It is supported upon a submucous areolar tissue, in which both the blood vessels and nerves ramify, but do not in any case enter the mucous membrane.

In order to examine the surface of mucous membranes, the mucus should be washed off as gently as possible, by a small stream of water or a small syringe. If the epithelium be required, it may be detached from the surface with a scalpel, placed on a glass slide, and viewed as a transparent object, with a power of 200 diameters. The mucous membrane itself may be seen by reflected light while under water; a movable dissecting microscope being brought over it. In order to obtain a correct idea of the external surface, sections, both horizontal and vertical, should be taken and submitted to high powers. When the membrane cannot be well cut into thin slices, it may be separated with the needles, or by slight pressure in the compressorium. Where epithelium is so abundant as to

form a layer of cuticle, it must be removed by maceration, in order to see the mucous surface.

The arrangement of the capillaries, as seen in the injected mucous membranes, is exceedingly interesting, and forms a numerous class of preparations.

CILIARY MOVEMENT.—If the roof of the mouth of a living frog be scraped with the end of a scalpel, and the detached mucous matter placed on a glass slide, and examined with a power of 200 diameters, the epithelium cells, and the movement of their cilia, may be well seen. The most common method is, however, to cut off with a pair of fine scissors a small portion of the gills (branchiæ) of an oyster or mussel; lay it on a slide or on a tablet of an animalcule cage, with a drop or two of the fluid from the shell. With the needle-points separate the filaments from each other, and cover it lightly with a thin piece of glass. The cilia may then be seen in several rows, beating and lashing the water with amazing activity. If fresh water be added instead of that from the shell, the movement will speedily stop. The motion and structure of the cilia is sometimes better observed after the lapse of some hours, as the movement will then have become sluggish.

INJECTED PREPARATIONS.—We have already referred to the arrangement of the capillaries in mucous membranes, muscular tissue, the eye, &c. A collection of such preparations is of considerable importance.

There can be no doubt, but that the blood is, *par excellence*, *the* vital fluid. From it is derived the material for the development of each part of the organization; nerve, as well as muscle, bone, tendon, &c. Even unnatural and morbid growths must have their origin in some alteration in this all-pervading, all-sustaining fluid. "The life thereof is the blood thereof."

The capillary vessels of the body form the vehicle of vital

distribution and stimulus. By them is conveyed the nutrition of all the tissues; and through them all foreign substances are extracted, and the blood thus rendered pure and vital. By endosmotic action through their thin coats in the lungs, oxygen unites with the carbon, and probably the iron of the blood, and carbonic acid gas is expelled; and from their peculiar arrangement in the kidney, lobules of the liver, &c., effete matters are strained, as it were, from the circulation, and carried off.

But there is another function, of equal, if not superior, importance with those just mentioned, which, in the judgment of the author of this work, the capillaries are destined to subserve. They are, doubtless, the cause, perhaps the sole cause, of the difference in the sensations experienced in the various organs and tissues of the animal frame, under the stimulus of the varied excitants to which the organization is subject in health and disease. The nervous cords may transmit impressions to the sensorium, but it is the stimulus of the blood—the vital fluid—variously modified by the capillaries, which determines the character of those impressions. Hence we find that those parts which are but slightly supplied with capillary vessels are comparatively dull of sensation, and *vice versa*. How otherwise can we account for the different sensations produced by inflammation in different tissues; as for instance, the burning, pungent pain of inflamed skin, contrasted with the dull, aching sensation of inflammation in the fibrous tissue.

May not the peculiar and delicate arrangements of the capillaries in the different coats of the eye; the ear; the papillæ of the skin; and other organs of special sense; be referred to the same design?

Other physiological facts also tend to establish this view. "If the abdominal aorta be tied, the muscles of the lower extremities will be paralysed, and on removing the ligature,

and allowing the blood to flow, the muscles will recover themselves." (*Todd and Bowman.*) We know, too, that the stimulus of too much, or too rapid, blood on the brain, will produce delirium, and illusions of special sense:—impressions being made on the sensorium independent of the action of usual external stimuli.

The theory above referred to, in order to explain or account for these phenomena, may be expressed as follows:—The principle of life, or the capacity for vital action, is a property impressed by the Great Creator upon the material organization of both animals and vegetables. In addition to this, the properties of sensation and volition have been imparted to all animals. These properties point out the existence of a spiritual being or entity (distinct from vital organization), which holds its connexion with each part of the animal frame by means of the nervous system. It is, however, essential to the integrity of this connexion, and to the proper performance of the functions of volition and sensation, that the nerves should be supplied with the proper vital stimulus of the organization—the blood—and the mode in which this stimulus is supplied, will determine the character of the impressions made upon, or received by, the entity or being referred to.

This entity, which some have confounded with the vital principle, acts through the nerves in a manner peculiar to itself. The force or material by which it holds connexion with the bodily frame is not electricity, although in some respects its properties are analogous. Messrs. Todd and Bowman present the following arguments, which prove conclusively the last remark. They show that the electric fluid could not be sufficiently insulated in the minute nerve-tubes to enable them to be proper conductors—that the most delicate tests of electricity fail to discover it, when applied to nerve in action—that a ligature to a nerve stops the propagation of nervous power, but

not of electricity—that if a piece of nerve be cut out and be replaced by an electric conductor, electricity will be transmitted when applied, but no nervous force excited by stimulus above the section will pass to the parts below—and that both nerve and muscle are infinitely worse conductors of electricity than copper or other metals. These facts are clearly opposed to the present popular theory of the identity of nervous force and electricity.

More extended remarks upon our theory of the cause of sensations would be out of place in a work of this kind; yet as the varied shapes and arrangement of the capillaries must be demonstrated by means of the microscope, and as we have seen no theory which attempts to explain the design of such variations, an allusion to this seemed to be appropriate.

It may be mentioned, however, that this view will throw great light upon the cause and cure of insanity, as well as other diseases; and upon the *modus operandi* of many articles of the materia medica. It is, indeed, a question worthy to be entertained, whether diseases, which are so clearly divisible into sthenic and asthenic, may not, after all, chiefly result from an alteration of tone or capacity in the capillaries of an organ, tissue, or of the whole system. Cullen's idea, that fever is caused by a spasm in the capillaries, may not be far from the truth, though it be but a theory.

To sum up all which our present limits will allow; the capillaries are the most interesting and important vessels of the body, and yet, perhaps, the least studied. A work specially devoted to them—their description and properties—would be a valuable accession to physiological science.

9

CHAPTER VII.

THE discovery of this class of objects by Dr. Goring, a full account of which may be found in Mr. Pritchard's works on the Microscope, was the chief cause of the modern improvements in the achromatic compound microscope.

Mr. Pritchard, following Dr. Goring, divides test objects into two classes, viz., tests of the penetrating power, and tests of the defining power of the instrument; the first showing its destitution of spherical and chromatic aberration, and mechanical imperfection; and the other class showing its angle of aperture.

This distinction is not now necessary, as few persons, save those engaged in the manufacture of object-glasses, attend to the former, the improvement in achromatic object-glasses having been so extensive that a good instrument, in this respect, is readily procurable. Still, it may be well to give an outline of the means by which the presence or absence of achromaticity may be known.

Chromatic aberration is rendered sensible by almost any transparent object, when the light falls upon it obliquely; but more especially by such as are not transparent, but only illuminated by intercepted light, of which a very good example may be seen in a piece of fine wire sieve, treated like a diaphanous object, also in a thin plate of metal perforated by very

small holes. The various colours are seen according to the order of their refrangibility, by putting the object both within and without the focus, as well as by viewing it at the focal point.

Spherical aberration is most sensibly felt in viewing opaque objects, especially if of the brilliant class. It shows itself in a variety of ways: first, as a diffused nebulosity over the whole field of view; secondly, as a confined nebulosity, extending only to a certain distance from the object; and thirdly, in a want of sharpness and decision in the outline caused by a penumbra or double image, which can never be made to lap perfectly over the stronger or true one. Destitution of spherical aberration is evinced by the absence of these appearances, and by the vanishing of the image immediately that the object is put out of focus either way.

To ascertain the defects alluded to above, a minute globule of mercury on a black ground, known as an "artificial star," is used. It presents a very minute point of light. Very minute globules of mercury, spread over a blackened surface, are viewed as opaque objects, being illuminated by the light from a window or lamp thrown on them by a condensing lens. When one of these globules is in the focus of a single lens object-glass, a strong coma surrounds the miniature image of the window seen in the globule, and when within or without the focus, the light of the window swells out into a circular disc. These appearances are more or less accompanied by prismatic colours.

When an achromatic combination, perfectly corrected for both kinds of aberration, is employed, the globule should exhibit similar appearances both within and without the best focus; and when at the focus, the point of light should be seen as a minute disc, free from irradiations and colour, except a general blueness, which results from the irrationality of the spectra of the different glasses of which the object-glass is composed.

Power of definition depends, in a great measure, upon the angle of aperture of the object-glass. A deficiency of angular aperture is shown by a want of light, producing unsatisfactory vision, which is rather increased than ameliorated by augmenting the intensity of the artificial illumination; by an incapacity of showing lined objects, except such as are of the lowest class; and by giving very large spurious discs with artificial stars; also by showing easy test objects with the lines faint, while the spaces between them are darker and more opaque than they ought to be.

When the aberrations are properly corrected, and the angle of aperture considerable, the lines on test objects become fine, sharp, and dark, and the spaces between them bright, provided the illumination has been properly conducted; they moreover become visible in a very faint light; the outline and the lines are seen at once; and the spurious discs of all brilliant points are very sharp and small.

In order to explain more fully what is meant by angular aperture, let A and a, Figs. 23 and 24, represent two objects, in all respects alike; and suppose B, B, and b, b, to be two object-glasses of equal focal length; the former a single lens, of the best construction, such as was used in the old compound microscope, and the latter a lens of the newest form, termed an achromatic. Now these object-glasses will form their respective images at I and i, and they will be of equal dimensions. But if the number of rays proceeding from A and falling upon the single lens B, B, is not enough, when collected at I, sufficiently to stimulate the eye, any minute pore, stria, or other marking at A, will not be rendered visible; while from the increase of aperture in b, b, allowing much more light to be transmitted, every mark at a will be represented at i, and the eye being powerfully acted on by the increase of light, will be highly sensible of it.

The angles B, A, B, and b, a, b, are the angles of aperture of the respective object-glasses, and the quantity of light transmitted will be as the squares of B, B, and b, b, their focal length being equal.

Fig. 23.
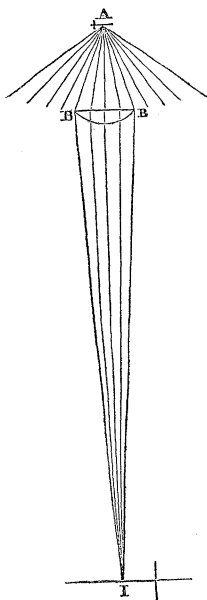
Fig. 24.
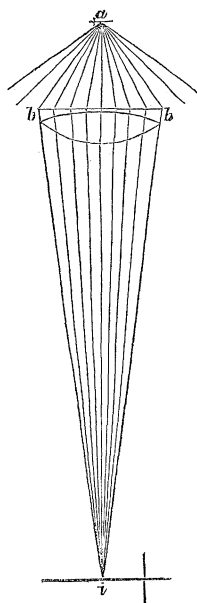
It may be supposed, that if we throw more light upon an object, so that more may be collected by the object-glass, we shall be better able to define its structure; and this would probably be the case if we could throw light only upon those minute parts which we wish to examine, and not upon the whole object, but as we cannot increase the relative proportions of light, the advantages proposed cannot be derived.

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In examining test objects it will be well to remember that there are generally some very easy ones, even among samples of the most difficult kind. The darker the specimen, the more easily is it made out; and the more transparent the tissue, the greater difficulty there is in developing its structure. Great attention too should be paid to the proper illumination of the object, or a superior instrument will be undervalued.

The following list affords an account of those objects most frequently used as tests of the defining power of the instrument.

BAT'S HAIR.—This is a most beautiful structure, presenting a series of scale-like projections arranged in the form of a whorl around the central part or shaft. They are least numerous at the base of the hair, and increase towards the apex.

MOUSE HAIR differs materially from the other in size and structure. Their internal structure is cellular, there being three or more rows of cells in each hair, the colour of the hair depending on the pigment within the cells. Under the microscope all hairs should have their light or transparent parts clearly and distinctly separated from the darker portions, and it is from the sharpness with which the parts are separated that a correct opinion of the value of an instrument can be obtained.

In selecting hair of animals for examination, the lightest coloured should be preferred. Like the scales on insects, the hair from different parts of the same individual varies considerably in structure.

HAIR OF THE DERMESTES.—This very remarkable hair is obtained from the larva of a small beetle, which preys on dried animal substances, as bacon and hams. It is covered with brownish hairs, the longest of which are selected.

The shaft of this hair is covered with whorls of close-set spines, and at the head is invested with a curious arrangement, consisting of several large filaments or spines, which are

pointed at their distal extremities, and provided with a protuberance at their proximal ends.

This object, with the others above noticed, is a good test of the defining power of a half-inch object-glass.

SCALES OF INSECTS.—The dust on the wings and bodies of butterflies, moths, and other insects, prove, on microscopic examination, to be scales or feathers, overlapping each other like the shingles on the roof of a house. They vary much in form and size ; and from the difficulty of developing their structure, they form excellent test objects. In the present list the most easy are first named.

Lepisma Saccharina.—These silvery-scaled insects frequent closets, book-shelves, &c., and are very common. Their scales are very pretty objects, but are so easily made out as hardly to deserve the name of test objects. The longitudinal striæ appear to stand out in bold relief, like the ribs of a shell. A good glass should show well the contrast between the striæ and the interspaces.

Morpho Menelaus.—The pale blue scales from the upper surface of the wing of this splendid butterfly form a good test for the half-inch object-glass, which should show clearly the transverse as well as the longitudinal striæ, giving it a brickwork appearance. If the scale be flat, which is not common, the striæ should be seen over the whole surface. Sometimes the scales are damaged, the pigment having been removed; in such cases the cross striæ cannot be seen. The pigment, under very high powers, exhibits a dotted appearance between the striæ.

Tinea Vestianella, or Clothes Moth.—The scales of these insects are very delicate, and require some tact in the management of the illumination to resolve their lines distinctly. The small scales from the under side of the wing should be taken; the others are easy.

Poutia Brassica, or Common Cabbage Butterfly.—The pale, slender, double-headed feathers, having brush-like appendages at their insertion, are good test objects. The specimens which are easily resolved are short, broad, and more opaque. The striæ are longitudinal, and with a power of 500 diameters appear to be composed of rows of little squares or beads.

Podura plumbea, or Lead-Coloured Springtail.—The body and legs of these tiny creatures are covered with scales of great delicacy. The surface of each, under a power of 500 diameters, appears covered with numbers of delicate wedge-shaped dots or scales, arranged so as to form both longitudinal and transverse wavy markings. A very small scale is a good test of the defining power of a one-twelfth or one-sixteenth-inch object-glass. The small scales may easily be rubbed off the scale to be examined, unless great care be taken in mounting, &c., and, of course, it will be useless as a test object.

SHELLS OF INFUSORIA.—Several delicate species serve as test objects. The so-called longitudinal and transverse striæ are resolved by superior instruments into dots or bead-like projections from the surface. The *Navicula hippocampus, N. angulata, N. Spencerii,* &c., have been recommended as tests. A species marked *Navicula attenuata,* is a good object, requiring delicate illumination under a high power, in order to show the longitudinal striæ or dots. Several kinds of Tripoli may also be used for the purpose.

As it is always a tedious matter with the use of a high power to find a minute object on the slide under the stage, it will be most convenient to bring it first into the centre of the field by the use of a lower power, and afterwards substitute the high power object-glass.

CHAPTER VIII.

ON DISSECTING OBJECTS FOR THE MICROSCOPE.

REFERENCE has already been made in Chapter V. to the manner of dissecting and preparing certain animal and vegetable tissues, yet much has been omitted, which may perhaps be more fully appreciated under the present head.

The instruments required in microscopic dissections; or minute anatomy; are various kinds of forceps, scissors, scalpels, needles, troughs, loaded corks, and arm-rests.

The forceps, in addition to the ordinary forceps used in coarse or rough dissection, may be made with closely-fitting, sharp points. The scissors are similar to those used for surgical purposes. It is useful to have a pair with the point of one of its blades blunt and truncated, for cutting open tubular parts, as the alimentary canal. Scissors with curved blades are also of service. A pair of very small scissors, whose

Fig. 25.
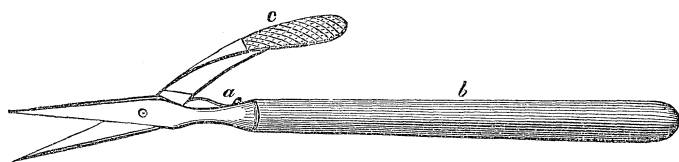
blades are kept open by a spring, *a*, Fig. 25, was much used by Swammerdam in his dissections. One of the handles is

attached to a piece of wood, *b*; the other is curved as at *c*, in order to be pressed upon by the thumb or forefinger in the act of cutting.

The ordinary scalpels or knives are usually too large for all purposes; those, however, which are used in operations on the eye will be of service.

For making fine sections, a scalpel or a razor may be employed, but for soft substances, as the liver, spleen, and kid-

Fig. 26.
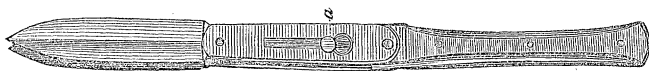
ney, a knife with two parallel blades, called Valentin's Knife, Fig. 26, may be used with advantage. Dissecting needles may be straight or curved. One of the latter, fixed in a proper handle, is represented in Fig. 27. These are very serviceable instruments for separating or tearing asunder delicate tissues.

Fig. 27.

As most dissections are made under water, convenient troughs are necessary. They may be from two inches to a foot long and of a proportionate breadth and depth. Earthenware, or glass, is the best material.

Loaded corks are flat pieces of cork covered on their under surface with sheet lead, so that they may readily sink in the water. To these corks the subject to be dissected is fastened with pins.

Rests are inclined planes of wood; one on each side of the trough holding the specimen. If the Dissecting Microscope represented by Fig. 5, is used, neither rests nor troughs will be required, other than are furnished with the instrument; unless it be troughs for specimens not immediately under examination.

In addition to these instruments, a small syringe, camel's-hair pencil brushes, &c. &c., will be found useful.

The following account of Swammerdam's dissections commends itself to all microscopists. It is condensed from an extract in Adams's Essays, from Boerhaave's Life of Swammerdam.

In the preparation of objects, no man was ever more successful or more indefatigable than Swammerdam. His chief art seems to have been in constructing very fine scissors, and giving them an extreme sharpness ; these he made use of to cut very minute objects, because they dissected them equally, whereas knives and lancets, if ever so fine and sharp, are apt to disorder delicate substances. His knives, lancets, and styles, were so fine that he could not see to sharpen them without a magnifying glass.

He was also dexterous in the management of small glass tubes, which were no thicker than a bristle, and drawn to a fine point at one end, but thicker at the other. These he made use of to show and blow up the smallest vessels discoverable by the microscope; to trace, distinguish, and separate their courses and communications, or to inject them with subtile liquors.

He used to suffocate insects in spirits of wine or turpentine, and likewise preserved them some time in these liquids; by which means he kept the parts from decomposition, and added to them such strength and firmness as rendered the dissections more easy. When he had divided transversely the little creature he intended to examine, and carefully noted every-

thing that appeared without further dissection, he then proceeded to extract the viscera in a very cautious and leisurely manner; first taking care to wash away and separate, with fine pencils, the fat with which insects are plentifully supplied.

Sometimes he put into water the delicate viscera of the insects he had suffocated; and then shaking them gently, he procured himself an opportunity of examining them, especially the air-vessels and trachea, which by this means he could separate from all the other parts. Again, he has frequently made punctures in other insects with a needle, and after squeezing out all their moisture through the holes made in this manner, he filled them with air, by means of slender glass tubes, then dried them in the shade, and anointed them with oil of spike, by which means they retained their proper forms for a long time. He had a singular secret whereby he could preserve the nerves of insects as limber and perspicuous as ever they had been. Some insects he injected with wax instead of air.

He discovered that the fat of all insects was perfectly soluble in oil of turpentine; thus he was enabled to show the viscera plainly, only after this operation he used to cleanse and wash them well and often in water. He frequently spent whole days in thus cleansing a single caterpillar of its fat, in order to discover the true construction of this insect's heart.

His singular sagacity in stripping off the skin of caterpillars that were on the point of spinning their cones deserves notice. This he effected by letting them drop by their threads into scalding water, and suddenly withdrawing them; for by this means the epidermis peeled off very easily; and when this was done, he put them into distilled vinegar and spirit of wine, mixed together in equal proportions, which, by giving a proper firmness to the parts, afforded an opportunity of separating

them, with very little trouble, from the exuviæ, or skins, without any danger to the parts; so that by this contrivance the pupa could be shown to be wrapped up in the caterpillar, and the butterfly in the pupa.

Those who look into the works of Swammerdam, will be abundantly gratified, whether they consider his immense labour and unremitting ardour in these pursuits, or his wonderful devotion and piety. On one hand, his genius urged him to examine the miracles of the Great Creator in his natural productions; while, on the other, the love of that same All-perfect Being, rooted in his mind, struggled hard to persuade him that God alone, and not his creatures, was worthy of his researches, love, and attention.

To render this section more perfect, a few further remarks on the internal anatomy of insects will not be out of place. For the anatomy of other parts of the animal organization, the reader is referred to Chapter V., and the usual text books.

1. *Tracheæ*, or *Respiratory System of Insects.*—Respiration in insects is effected by means of two great longitudinal vessels or canals called tracheæ, running along the sides of the body beneath the outer integuments and muscles, terminating in breathing pores (spiracles or stigmata). These pores or spiracles are placed along each side of the body in terrestrial insects, and are furnished with a beautiful mechanism to prevent the admission of foreign particles. The tracheæ emit an infinite number of ramifications, extending to all parts of the body, so that air circulates freely in every part. The tracheæ consist of an elastic spiral cartilage rolled up into a tube, lined on each side with cellular tissue. In Fig. 28 the tracheæ of the larva of the *Cossus ligniperda*, or willow moth, is represented. Along each side of the caterpillar are seen the spiracles.

To obtain the tracheæ, &c., the insect should be placed in a

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small trough with water, and be securely fixed to a loaded cork.
The body being laid open, next to the large viscera, the tra-
cheæ will become visible.   The stomach and intestinal canal,
if large and transparent, will exhibit the minute ramifications

Fig. 28.
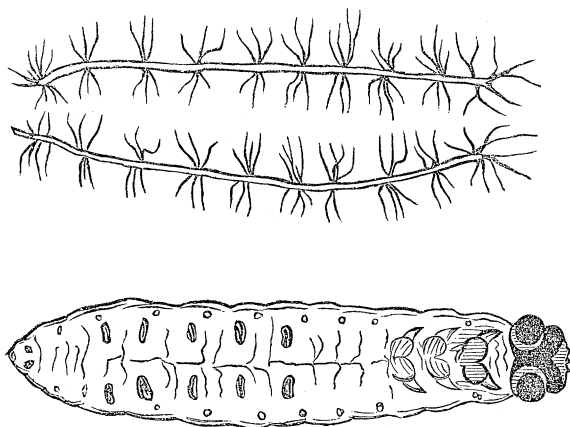
of the tracheæ the best; for this purpose, after being slit
open and well washed, they should be either mounted in fluid
or be placed on a slide to dry.   If care be taken in the mount-
ing, they will show very well in balsam.   When the entire
tracheal system is required to be dissected from the larva of
an insect, all the viscera should be taken out; the main
trunks with their tufts of branches, will then be seen running
down on either side of the body, and if care be taken in the
dissection, the whole system may be removed from the cavity,
and laid out, or rather floated on, a slide to dry, previous to
being mounted in balsam.   The spiracles require very little

dissection. They may be cut from the body with a scalpel or pair of scissors, and be mounted in fluid or in balsam.

2. *The Digestive System* consists of the pharynx; the eso-phagus, or gullet; the craw, or crop; the gizzard, or ventri-culus; the stomach, or duodenum; the intestines; and a number of slender membranous tubes filled with a fluid analogous to bile. In addition to these, the salivary glands may be mentioned.

There is very great variety in the digestive apparatus of insects. In those which feed on flesh, the alimentary canal is short, as in the higher animals, and in the vegetable eaters it

Fig. 29.
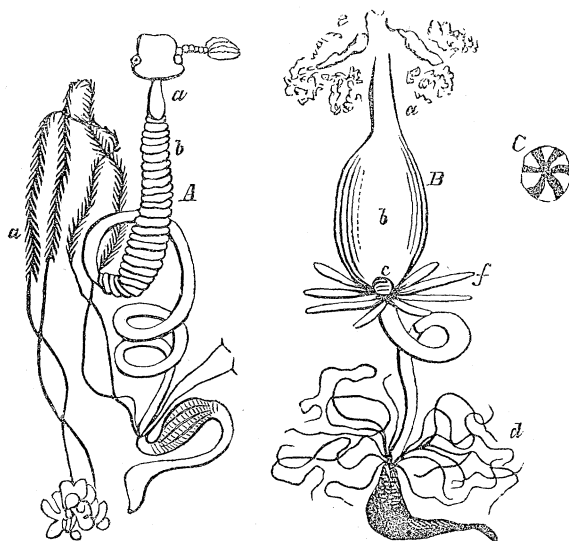
is long. There are also differences of structure, which clearly show the adaptation of means to ends. A, Fig. 29, is the digestive system of Melolontha. B, is that of Blatta Ameri-

cana (American Cockroach), a is the esophagus, b the crop, at the bottom of which is the gizzard, c, consisting of several teeth arranged like a funnel, with the apices of the teeth in the centre.   Another view of the gizzard is seen at C.   The bile-tubes or liver are shown at d, and the salivary glands at e. Attached to the stomach, just below the gizzard, are eight blind sacs, f, the use of which is unknown, but is supposed to be analogous to the pancreas.

The salivary glands, stomach, &c., should be generally mounted in fluid.   Gizzards may be put up in balsam.   The gizzard of a cricket is an interesting object; it has over two hundred teeth.

3. *The Nervous System* consists of two medullary cords or threads, which run along the middle of the abdomen inside, exhibiting a series of knots or ganglia.

Fig. 30 exhibits the nervous system of a caterpillar, from a preparation of Dr. Goadby's.   The double ganglion, A, seems to occupy the place of the cerebellum, and B, also double, and transverse to the others, answers to the cerebrum.   C, C, the two cords uniting them.   E, the space through which the esophagus passes.   F, F, F, the ganglia which unite the two cords.   The distribution of the nerves through the body is from the ganglia.   The apparent exceptions to this, as at D, are proven, by Dr. Goadby's investigations on the Limulus, to be, in fact, arteries, as they have been injected.   Coagulated insect blood is white, hence they appear like nerves.

4. *The Circulatory System* is placed along the back, and consists of a heart or dorsal vessel; which is a tube divided into chambers, separated from each other by valves.   There are also valves at the sides to receive the blood from the venous sinuses of the body.   But a single artery has been seen, which goes to the head, dividing into three branches.   It was thought that the blood exuded through the vessel and found its way through the body as it best could, back to the heart; but in

dissecting a Limulus (king-crab), Dr. Goadby traced the artery
into certain large sacs or vessels, evidently answering the pur-
pose of veins (venous sinuses). It is probable the same holds

Fig. 30.
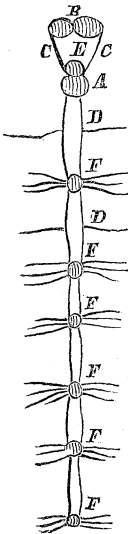
Fig. 31.
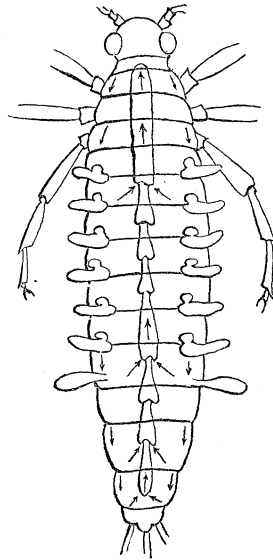
good of insects. Fig. 31 represents the dorsal vessel in the
larva of Ephemera. The arrows indicate the current of the
fluid.

The muscular system of insects is very extensive. Lyonet
dissected and described 4061 in the caterpillar of the goat moth
(*Cossus ligniperda*).

10*

CHAPTER IX.

REFERENCE has already been made at page 96 to the cause of vitality; alluding to it as a peculiar property impressed by the Creator on all organized structure,—a property altogether distinct from Volition and Sensation, which exclusively belong to animals, and which point out the existence of a special entity, or being, resident in the organism, but whose properties cannot properly be referred either to matter or its organization.

Respecting the essential nature of the vital principle, much speculation has been uselessly employed. Some have confounded it with the entity, or being, in the animal, which *perceives* and *wills*. But this is manifestly an error, inasmuch as it pertains also to vegetables. Very many parts of the organization, also, have an independent vitality (without special sensibility), separate from that of other parts, as we shall see in the progress of this chapter. It seems, therefore, most reasonable to define it as a peculiar property of organization; as gravitation, electricity, &c., are special properties of matter under other circumstances, the essential nature of which are just as mysterious as that of Life.

Mysterious as this subject is, it is nevertheless interesting to trace the origin and development of organized structures; and the progress of modern science has supplied us with the means

of instruction.   Chemistry teaches us that the ultimate ele-
ments of organized bodies are identical with the elements of
other bodies; and the microscope detects the earliest forms
produced by the vital process, and the part sustained by them
in the development of each species.

Chemical analysis shows, that what are termed *simple ele-
ments*, as oxygen, hydrogen, carbon, nitrogen, sulphur, &c.,
are peculiarly arranged in all organized bodies; having special
affinities which they do not possess in unorganized substances,
or bodies destitute of life.   These peculiar affinities form a
class of compound substances called *proximate principles*, or
organic compounds, or *organizable substances*.   They are ob-
tained by the analysis of organized textures : such are *albumen,
fibrin, starch, gluten*, &c.

Owing to the feeble affinity of the simple elements in the
organic compounds, there is a great tendency in them to enter
into new combinations, forming what are called *secondary
organic compounds*.   Such are *urea, uric acid, pepsine, sugar
of milk*, &c.

Hitherto, no one has succeeded in producing the true proxi-
mate principles by chemical synthesis, and it is doubtful if
they will ever be produced elsewhere than in the living organism.
Some of the secondary organic compounds have, however, been
formed in the laboratory of the chemist; as the production of
urea from cyanate of ammonia through the action of heat,
which has been effected by Wöhler.

" The simplest and most elementary organic form with which
we are acquainted, is that of a cell, containing another within
it (*nucleus*), which again contains a granular body (*nucleolus*)."
See Fig. 32.

" This appears, from the interesting researches of Schleiden
and Schwarm, to be the primary form which organic mat-
ter takes when it passes from the condition of a proximate

principle to that of an organized structure." (*Todd and Bow-man.*)

There are some animal tissues, however, which seem to have a lower grade of organization than cells, being apparently

Fig. 32.

produced by the simple solidification of the plastic or organizable fluid : this fluid is, however, prepared by cells, and is set free by their rupture. This seems to be the case with the delicate membrane known as the *Basement* or *Primary Membrane*, beneath the epidermis or epithelium. According to Dr. Carpenter, in many specimens of this membrane, no vestige of cell-structure can be seen, and it resembles that of which the walls of the cells are themselves constituted. In other cases it presents a granular appearance under the microscope, and is then supposed by Henlé to consist of the coalesced nuclei of cells, whose development has been arrested. Other specimens of basement membrane, however, described by Goodsir, present a distinctly cellular structure, the cells being polygonal, and each having its own granular nucleus.

Cells are formed in two ways; either in a previously existing, structureless fluid called a *blastema*, or within the interior of previously existing cells. In the first method, the plastic fluid becomes opalescent from the deposition of a number of *nucleoli;* several of these become aggregated, and form the *nucleus*, within which the nucleolus can still be seen. This nucleus is called the *cytoblast* (from κυτος, a vesicle, and βλαςος, a germ), or *cell-germ.* From the side of this nucleus a thin transparent membrane projects like a watch-crystal from the

dial, and gradually enlarges till at last the nucleus is seen only as a spot on its wall.   The whole is then called a *nucleated cell*, or *germinal cell*. The fluid in which the granules are first deposited is called the *cytoblastema*.

In the second method of development, each granule of the nucleus has the power of developing a cell, so that the parent cell becomes filled with one or more generations of new cells, which may either disappear entirely, or by the rupture of the original cells the contents may be scattered and undergo an independent development.

Sometimes several nucleoli are seen within one nucleus, and several nuclei within one cell.

Each cell is an independent organ, living for itself, and by itself, and depending upon nothing but a proper supply of nutriment and of the appropriate stimuli for the continuance of its growth and for the performance of its functions, until its term of life is expired.

The development of cells goes on at every period during the life of the organism.   They are found floating in immense numbers in the blood, chyle, and lymph ; and even in diseased secretions, as pus.   In the inflammatory process they are produced in great quantities ; and the malignant growths, such as cancer and fungus hæmatodes, which infest the body, are owing to the same agencies.   In short, the nucleated cell is the agent of most of the organic processes, both in the plant and animal, from the dawn of their existence to their full maturation and decline.

The forms of cells are various ; some being spheroidal, others cubical, prismatic, polygonal, or cylindrical.   They are subject also to various transformations.   Sometimes a number of cylindrical cells are laid end to end, and by the absorption of the transverse partitions form a continuous tube ; as in the sap vessels of plants, muscular and nervous fibre, &c.

At other times the cells are elongated and fusiform, as in

woody fibre; or they may send forth prolongations, assuming
a stellate or irregular appearance, as in the pigment cells of
the Batrachia and Fishes, or some of the vesicles in the gray
matter of the nervous system. Further, the original bounda-
ries of the cells may be altogether lost, from their coalescence
with each other; or their cavities be so occupied by internal
deposits that they may be mistaken for solid fibres.

The nuclei are also subject to change of form. In some
instances we find it sending out radiating prolongations, so that
it assumes a stellate form, like that of the cells of the Gera-

Fig. 33.
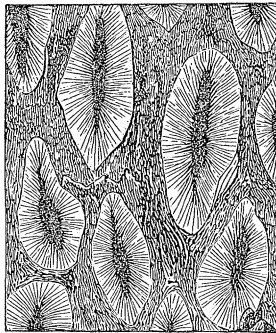
nium-petal, Fig. 33; this seems also to be the case with the
nuclei of the bone cells. In other cases it seems to resolve
itself into a fasciculus of fibres; and this Henlé conceives to be
the origin of the yellow fibrous tissue. Further, it may sepa-
rate into a number of distinct fibres, each composed of a linear
aggregation of granules; in this manner, the dental tubuli
appear to be formed. Lastly, Dr. Carpenter thinks it may
disperse itself still more completely into its component gra-
nules; by the reunion of which certain peculiar vibrating fila-
ments (the so-called spermatozoa) may be formed.

"In the lowest and simplest forms of living beings," says Dr. Carpenter, "such as we meet with among the humblest cellular plants, we find a single cell making up the whole fabric.   This cell grows from its germ, absorbs and assimilates nutriment, converts a part of this into the substance of its own cell-wall, secretes another portion into its cavity, and produces from a third the reproductive germs that are to continue the race; and having reached its own term of life, and completed the preparation of these germs, it bursts and sets them free—every one of these being capable, in its turn, of going through the same set of operations.   In the highest forms of vegetable life, we find but a multiplication of similar cells; amongst which these operations are distributed, as it were, by a division of labour; so that, by the concurrent labours of all, a more complete and permanent effect may be produced."

Of the development of animal tissues, Todd and Bowman present the following interesting account, in their "Physiological Anatomy and Physiology of Man."

"The prevailing mode, in which the development of animals takes place, is by the formation, within the parent, of a body containing the rudiments of the future being, as well as a store of nutrient material sufficient to nourish the embryo for a longer or shorter period. This body is called the *ovum* or egg. It is of that form which, in a former page (see Fig. 32, page 116), has been described and delineated as the simplest which organization produces.   It consists of a vesicular body filled by a fluid, and enclosing another, within which is a third, consisting of one or more minute, but clear and distinct granules. The first, or *vitelline* membrane of the ovum, is the wall of a cell; it is composed of homogeneous membrane : the second, or the *germinal vesicle* of the egg, is the nucleus of the first : and the third, which is called by embryologists the *germinal*

spot, is a nucleolus to the second. It appears, from the re-searches of Wagner and Barry, that the nucleus or germinal vesicle precedes the formation of the vitelline membrane, but the precise relation, as to the period of its formation, of the nucleolus or germinal spot to the nucleus, has not yet been satisfactorily made out. The germinal vesicle and spot become the seat of a series of changes, which give rise to the develop-ment of new cells, for the formation of the embryo.

" At this period the embryo consists of an aggregate of cells, and its further growth takes place by the development of new ones. This may be accomplished in two ways : first, by the development of new cells within the old, through the subdivi-sion of the nucleus into two or more segments, and the forma-tion of a cell around each, which then becomes the nucleus of a new cell, and may in its turn be the parent of other nuclei : and, secondly, by the formation of a granular deposit between the cells, in which the development of the new cells takes place. The granules cohere to each other in separate groups here and there, to form nuclei, and around each of these a delicate membrane is formed, which is the cell-membrane.

" In every part of the embryo the formation of nuclei and of cells goes on in one or both of the ways above mentioned ; and, by and by, ulterior changes take place, for the production of the elementary parts of the tissues."

The mode of development just referred to may be illustrated by the following cuts. Fig. 34 exhibits a section of one of the branchial cartilages of the young tadpole. Within the large parent-cells, that are held together by intercellular sub-stance, *a*, *b*, *c*, we observe secondary cells in various stages of development : at *d*, the nucleus is single ; at *e*, it is dividing into two ; in the adjoining cell, the division into two nuclei, *d'* and *e'*, is complete ; at *h*, two such nuclei are enclosed within a common cell-membrane ; at *i*, we see three new cells (one of

them elongated, and probably about to subdivide) within the
parent; and in each of the two groups at the top and bottom

Fig. 34.
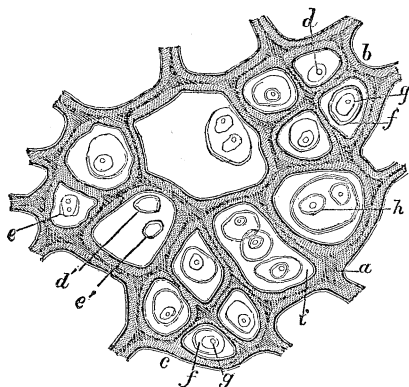
of the figure, we have four cells, separated by partitions of in-
tercellular substance, but having manifestly originated from
one parent cell.

Fig. 35 represents endogenous cell-growth in cells of a me-
liceritous tumour; *a*, cells presenting nuclei in various stages
of development into a new generation; *b*, parent-cell filled
with a new generation of young cells, which have originated
from the granules of the nucleus.

The following arrangement of animal tissues is based upon
that adopted by Dr. Carpenter.

1. Simple membrane; homogeneous, or nearly so, employed
alone, or in the formation of compound membranes. Its
principal character is extension, but its ultimate structure de-
fies the highest powers of the microscope.—Examples are seen
in the posterior layer of the cornea, capsule of the lens, sar-
colemma of muscle, &c.

11

2. Simple fibrous tissues, including the white and yellow fibrous tissue, and the areolar tissue, which is formed from

Fig. 35.
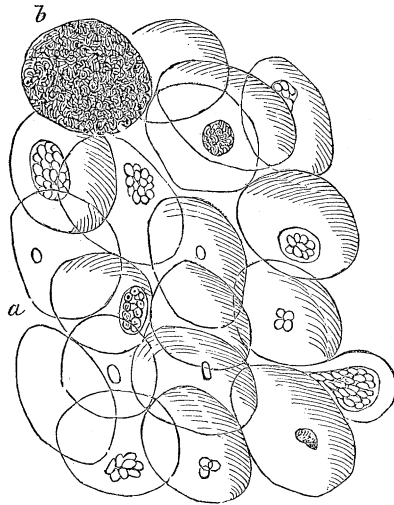
them.   Henlé believes the white fibrous tissue to be formed by cells; the yellow, by nuclei.

3. Simple cells, floating separately and freely in the fluids, as corpuscles of the blood, lymph, and chyle.

4. Simple cells developed on the free surfaces of the body, as epidermis and epithelium.

5. Compound membranes; composed of simple membrane, and a layer of cells, of various forms (epithelium and epidermis); or of areolar tissue and epithelium; as mucous membrane, skin, secreting glands, serous and synovial membranes.

6. Simple isolated cells, forming solid tissues by their aggregation; as fat cells, the vesicles of gray nervous matter,

absorbent cells of the villi, and the cellular parenchyma of the spleen. In these cases the cells are held together by the blood-vessels and areolar tissue, which pass in between them; in cartilage, and other tissues allied to it in structure, the cells are united by intercellular substance, either homogeneous, or of a fibrous character.

7. Sclerous or hard tissues, in which the cells have been more or less consolidated by internal deposit, and more or less completely coalesced with each other; as the hair, nails, &c. These instances may be more properly ranked under the epidermic tissues; the result of consolidated deposit is more characteristically seen in bones and teeth.

8. Tubular tissues; formed by the coalescence of the cavities of cells; as in the capillary blood-vessels, muscular fibre, tubuli of nerves, &c.

In some of these, as muscle and nerve, a deposit has taken place subsequently to the coalescence of the original cells.

To these we may add,—9. Compound tissue; formed of areolar tissue and cartilage; as fibro-cartilage.

CHAPTER X.

For the purpose of making a microscopic analysis of abnormal or other fluids, certain chemicals will be required; as liquor potassæ, ammonia, ether, and alcohol, acetic, nitric, hydrochloric and sulphuric acids; together with a few test-tubes and watch-glasses.

In the case of solids, the various kinds of scalpels, dissecting needles, and Valentin's knife, will be useful.

If the subject for examination be fluid, as blood, pus, mucus, &c., a very small quantity should be put on a clean slide, and covered with a piece of thin glass. A fishing-tube (page 47) will be of service for this purpose.

If there be sediment in the fluid, it should be allowed to subside, when it can be transferred by the fishing-tube to the slide. A small quantity of any reagent which may be desired, may be brought in contact with one of the sides of the thin glass cover, when it will gradually insinuate itself between the glasses, and act slowly on what is contained there. In other cases, the cover may be lifted up, and the reagent added.

In the case of blood, the fluids that require to be added are generally ordinary water; serum; and sugar or salt, dissolved in water; but in the case of pus and mucus, which approach

each other so nearly in many of their characters, it becomes of importance to have some test whereby they may be distinguished from each other. The fluid employed for this purpose is acetic acid. When this is added to a fluid where pus is present, the globules swell up, and several large, transparent nuclei make their appearance; but when it is added to a fluid where mucus is present, the globules also enlarge and show their nuclei, but not so plainly as the pus, and the liquid, termed liquor muci, in which the globules float, is instantly coagulated into a semi-opaque corrugated membrane.

The presence of fatty matter is ascertained by sulphuric ether, which readily dissolves the oily part, and leaves the membranous cell-wall untouched.

Earthy matters require the aid of the acids for their solution; these should be added in a dilute form, so that their solvent action may be more easily witnessed.

Solid parts, as tumours, &c., that are to be examined as transparent objects, with high powers, require to be cut into very thin slices, and separated, if necessary, by the needle-points. The sections should be placed on a slide, and a little serum, or white of egg in water, added, in order to float out certain of the parts, and to lessen the refraction of the light at the edges of the object. Water will answer the purpose for some of the hard tissues, but where nucleated or other cells, and nervous matter, are present, its use is inadmissible.

It is necessary to state, that the examination of all morbid structures should be made as soon as convenient after their removal from the body, as changes of form in the softer substances speedily take place; but if some time has elapsed, the part from which the sections are taken should be at some distance from the surface, in order that they may be as little altered as possible by the action of the air.

The foregoing directions have been condensed from those of

11*

Mr. Quekett, to whose book we have already been much in-
debted during the progress of this work.

It was at one time "fondly hoped" (says Dr. McClellan),
"that by the aid of powerful microscopes we could be able to
detect the pre-existing germs of all organic diseases in the
general circulation, and decide not only as to the species of
affection, but also concerning the degree of constitutional con-
tamination. It was even thought that cancers could thus be
distinguished from scrofula and all other more innocent dis-
eases; while, at the same time, we could form a conclusive
opinion as to the propriety of attempting or declining a sur-
gical operation, or of instituting any mode of local treatment
for the purpose of affording relief. But all such attempts
have proved to be illusory, and we can gather no other practi-
cal knowledge from the use of the microscope than what is
connected with the minute anatomy of the morbid structures
after they have been elaborated." With all deference to the
opinion of so truly a great mind as the lamented McClellan,
we may be permitted to remark, that notwithstanding much
has been done by the labours of European and other observers,
minute pathological observation is still in its infancy; yet it
has made a deep impression upon the study of medical science.
When "the minute anatomy of the morbid structures" shall
be fully known, our knowledge of organic diseases will have
advanced to a great degree of perfection. Dr. McClellan is
not himself insensible of the advantages to be derived from
microscopic investigations, although we think he places too
little value upon them. He says, "Chemical analyses and
microscopic researches have lately proved that a great number
of cases (of tumours) which were once thought to be scirrhous,
or cartilaginous, or osteo-sarcomatous, are really composed of
condensed fibrine of the blood, sometimes partially altered into
albumen or gelatin."

The microscopic appearance of a fibrous tumour is exhibited in Fig. 36 (after Vogel).   It shows interlacing fibres, C. Pri-

Fig. 36.
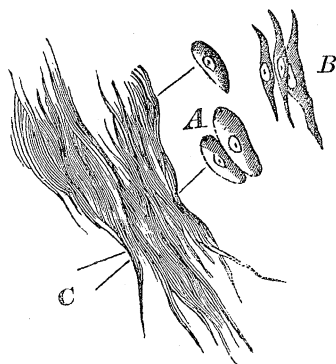
mary cells with nuclei and nucleoli, A, and the same cells elongated and becoming caudate, B.   The interlacing fibres appear to be identical with the fibres of coagulated lymph.

Malignant growths may be divided into three classes of disease. 1. Scrofula, and its varieties. 2. Carcinoma, or scirrho-cancer.   3. Encephaloid disease, or medullary fungus.

1. Scrofulous growths present three forms of manifestation. In the lymphatic ganglia and in the conglomerate glands; in well-defined spherical tubercles, which appear first as small points or grayish granules; and depositions which appear during the progress of typhus fever, between the muscular and mucous coats of the intestines, in the mesenteric glands, in and under the mucous membrane of the trachea, and some-times in the substance of the lungs and spleen. Fig. 37 shows the microscopic appearance of typhous matter from the mesen-teric glands.   A, an amorphous, slightly granular mass, of a

brownish-white colour, with an immense number of cells deposited; B, the amorphous mass treated with acetic acid, by which it was rendered transparent, and gradually dissolved,

Fig. 37.
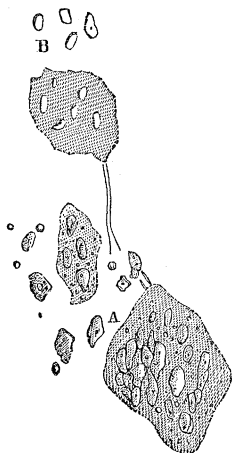
upon which many minute cells with a sharp outline came into view, being unaffected by the acid (Vogel).

There seems no distinction between tuberculous matter and that of scrofula or typhus. Fig. 38 exhibits tubercles in various stages of development. A, B, C, tubercles from the lungs of a young man who died of tuberculosis pulmonum.

A, B, nuclei in an amorphous cytoblastema; most of the nuclei contain nucleoli. At C the cytoblastema has disappeared and the cells are in contact. D, tubercular cells from the lungs of another young man. Here the cytoblastema has also disappeared, and the nuclei are enclosed in a cell-wall; no nucleoli are present.

2. Carcinoma.   In cases of true scirrhus, the matrix or
stroma is constituted either by a new development of cellular
texture, or by an induration and enlargement of the original
areolar tissue of the part.   The larger and coarser fibres and

Fig. 38.
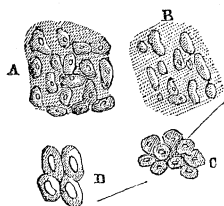
lamellæ of this tissue become converted into dense and firm
ligamentous bands, which intersect each other in various
directions.

Vogel, and some other writers, describe a second kind of
fibres, which occur in a reticulated form, cross-barred, or in
irregular meshes.   They are distinguished from the first-men-
tioned whitish or ligamentous bands, by being insoluble in
acetic acid.   Fig. 39 (from Vogel, after Müller), shows the

Fig. 39.
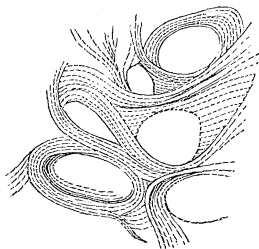
fibrous stroma of scirrhus, as seen in the microscope.   The

meshes are formed by bundles of carcinoma reticulare of the breast, as they appear after the globules have been removed.

The dense, firm, bluish-white, or yellowish and amorphous-looking substance which fills the interstices of the stroma is rendered transparent by acetic acid, and by ammonia and other caustic alkalies. This, though deposited in a fluid state, acquires its solidity by coagulation, after which it is thought that the peculiar cancer cells, or fibres, which constitute the malignant character of the disease, are developed.

The principal forms of cells which enter into the composition of cancerous growths are—1. The irregularly caudate or ramifying cells; 2. Larger cells filled with nuclei; and 3. Granular cells filled and covered with granules. Besides these Vogel describes cells with a thick wall, exhibiting a double contour; double cells formed by the division of one or the fusion of two cells; and pigment cells, enclosing dark, granular pigment.

The above are transitory or effete cells. The persistent or fibre cells are fusiform, such as occur in the development of areolar tissue, and of simple muscular fibre. They occur in the firm, rarely in the soft forms of cancer, and seem destined for the formation of the areolar tissue, and the intersecting ligamentous bands. In addition to all these, there appear numerous particles or granules of broken-down lymph and fat; large fat granules and globules; and a viscid, gelatinous fluid. These latter, however, may be considered adventitious and not essential formations.

The microscopic appearance of scirrhus (220 diameters) is exhibited in Fig. 40. Small masses that had been pared from a recent section of the tumour, and moistened in water, consisted entirely of an accumulation of cells. These were very pale, varying in size and form, being sometimes roundish, *a*, sometimes oval, *b*, or caudate, *f*, or again of irregular form.

The greater number exhibited nuclei, *a, b,* and in some a nu-
cleolus was visible in the nucleus, *c, h;* few were devoid of

Fig. 40.
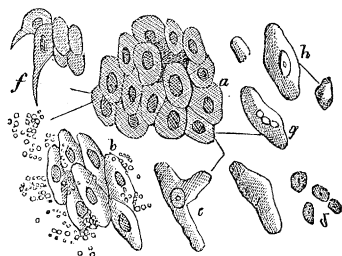
nuclei; on some fat globules were observed, *g.* Between
these cells were perceived nuclei with or without nucleoli, *d.*
(Vogel.)

3. Encephaloid disease or fungoid tumour, differs from
scirrhous cancer chiefly in the great predominance of its transi-
tory or morbidly developed cells over the fibrous and other
elementary textures which constitute the stroma (matrix) of
the tumour. In carcinomas, the fibrous tissue predominates
and gives solidity and firmness to the whole mass. The morbid
or cancer cells never tend to develope organized fabrics, but
always to disintegration and softening down of the tumour.
Their great predominance in encephaloid, therefore, gives the
character of brain-like softness and yielding, which is the dis-
tinguishing characteristic of this form of malignant growth.

Fig. 41 represents encephaloid, from the liver, under the
microscope. It appeared wholly composed of cells, which
showed distinct nuclei and nucleoli. The cells were mostly
roundish or oval, but some were caudate. Acetic acid ren-
dered them full and brought the nuclei plainly in view, *a.*

Here and there some nuclei were seen in an amorphous cyto-blastema.

Fig. 41.
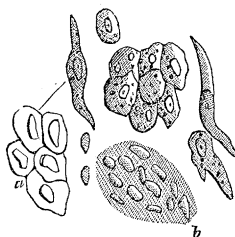
Although the cells of encephaloid belong to the class of effete or transitory cells which also occur in cancer, yet there is a difference in the proportions of various kinds of these cells in the two classes of tumours. The predominating cells of this kind in fungoid tumour are the very large parent cells, with numerous young cells or cytoblasts in their interior. They are often as large as $\frac{1}{30}$th of a line in diameter; and the caudate cells are always irregularly caudate or ramifying.

There are seldom any of the regular caudate or elongated cells of small size, such as go to the formation of the cellular and fibrous tissue, and of true cancers. The fat cells and granules are perhaps more abundant than in scirrhus. Fig. 42 is the microscopic appearance of encephaloid, consisting of cells of different size and form; round, oval, and caudate, but no one form predominating over the rest. Some are very large, a, enclosing several minute cells with nuclei. Isolated cells, although in a proportionately small number, contained dark granules, b. For further observations on microscopic patho-

logy, the reader is referred to Vogel's Pathological Anatomy, and other similar works.

Fig. 42.
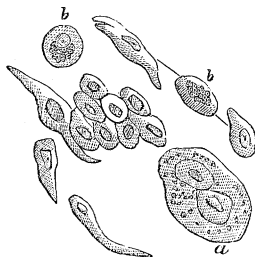
The Monthly Journal of Medical Science for May, 1847, contained an account of a new instrument for the diagnosis of tumours. It was presented to the Medical Society of Strasbourg, by M. Kün, Professor of Physiology in that city.

"It consists in an exploring needle, having at its extremity a small depression with cutting edges. On plunging this instrument into a tumour to any depth, we can extract a minute portion of the tissue of which its various layers are composed. In this manner a microscopic examination of the tumour can be practised on the living subject, and its nature ascertained before having recourse to an operation."

With respect to the Morphology of various pathological fluids, a great deal has been effected by microscopic investigation. In the Microscopic Journal, vol. ii., is a series of essays on this subject, by Dr. David Gruby, translated from the Latin by S. J. Goodfellow, M.D., which are worthy of careful perusal and experimental verification. The results of Dr. Gruby's researches may be found in a tabular form at the end of this volume.

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CHAPTER XI.

MERE dissection, with the most artful management of the scalpel, cannot make a full exhibition of the true structure of animal bodies. The arteries are found, after death, to be emptied of their contents, and the blood is coagulated in the veins, which appear much collapsed; hence anatomists, in order to examine the circulatory apparatus, are under the necessity of filling these vessels by means of injection, in order to distend them as much as possible, that their ramifications may be clearly seen. More especially is this necessary when it is desired to make an exhibition of the minute capillaries, which are so variously arranged in the different textures and organs of the body. These small vessels, too, require the aid of the microscope to show their size, form, and arrangement.

The ordinary coarse injection, may be made by melting together 16 ounces of bees'-wax, 8 ounces of resin, and 6 fluid-ounces of turpentine varnish, adding such colouring matter as may be desirable, as 3 ounces vermilion, 2 ounces King's yellow, 10 ounces blue verditer, or 5½ ounces flake-white.

This, injected into the blood-vessels by a proper syringe, having its pipe fastened in one of the largest of those vessels, is abundantly sufficient to show the course of the principal arteries and veins. The parts so injected may then be dis-

sected for this purpose, dried, and varnished, and form excellent illustrations of anatomical lectures.

When, however, it is desired to demonstrate the capillaries, a finer injection and more delicate manipulation is required. Indeed, it is so difficult an art, and success is so dependent on the combination of various circumstances, that the most experienced are often defeated in their efforts. Yet some of the finest injections I have ever seen were made by those who attempted it for the first time.

For minute injection (as it is called), the most essential instrument is a proper syringe. This should be made of brass, of such a size that the tip of the thumb may press on the head or handle of the piston-rod when drawn out, while the body is supported by two of the fingers of the same hand.

Fig. 43 represents a syringe, with which I have succeeded in making some excellent preparations. A is the cylindrical brass body, on the top of which screws the cap, B, a leather washer being interposed to render it more air-tight. C is the piston, which is of brass, covered with wash-leather. The bottom of the syringe, D, also unscrews, for convenience of cleaning. E is a stop-cock, on the end of which another stop-cock, F, fits closely. On the end of this, one of the injection-pipes, G, which are of different sizes, may be placed. The transverse wires, across the injection-pipes, are designed for the better security of the pipe in the vessel into which it is fixed; the thread being tied behind them so that it cannot slip forwards. A half-dozen pipes, at least, are necessary to accompany each instrument.

In addition to the syringe, a large tin vessel to contain hot water, with two or three lesser ones fixed in it for the injections, will be found useful.

To prepare the material for injecting :—Take of the finest

and most transparent glue, one pound; break it into small
pieces, put it into an earthen pot, and pour on it three pints
of cold water; let it stand twenty-four hours, stirring it now

Fig. 43.
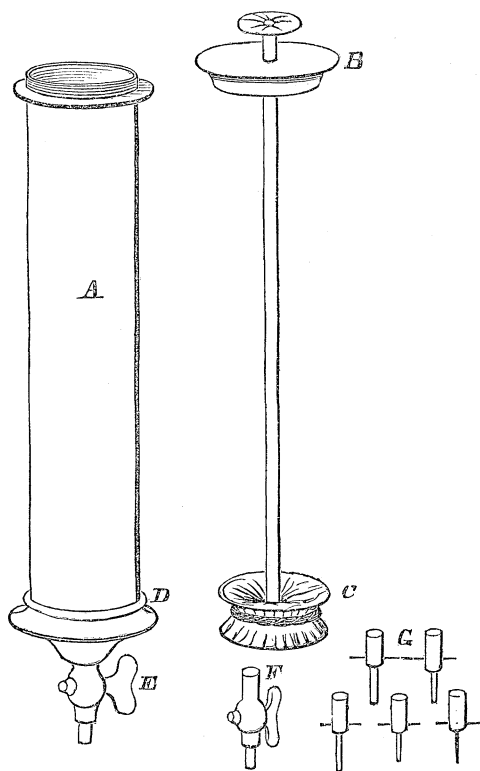
and then with a stick; then set it over a slow fire for half an
hour, or until all the pieces are perfectly dissolved; skim off

the froth from the surface, and strain through a flannel for use. Isinglass, and cuttings of parchment make an excellent size, and are preferable for very particular injections.

The size thus prepared may be coloured with any of the following :

Red.—To 1 pint of size, 2 ounces of Chinese vermilion.

Yellow.—Size, 1 pint,—chrome yellow, $2\frac{1}{2}$ ounces.

White.—Size, 1 pint,—flake-white, $3\frac{1}{2}$ ounces.

Blue.—Size, 1 pint,—fine blue smalts, 6 ounces.

It is necessary to remember that whatever colouring matter is employed, must be very finely levigated before it is mixed with the injection. This is a matter of great importance, for a small lump or mass of colour, dirt, &c., will clog the minute vessels, so that the injection will not pass into them, and the object will be defeated.

The mixture of size and colour should be frequently stirred, or the colouring matter will sink to the bottom.

Respecting the choice of a proper subject for injecting, it may be remarked, that the injection will usually go farthest in young subjects; and the more the creature's fluids have been exhausted in life, the greater will be the success of the injection.

To prepare the subject, the principal points to be aimed at are, to dissolve the fluids, empty the vessels of them, relax the solids, and prevent the injection from coagulating too soon. For this purpose it is necessary to place the animal, or part to be injected, in warm water, as hot as the operator's hand will bear. This should be kept at nearly the same temperature for some time by occasionally adding hot water. The length of time required is in proportion to the size of the part, and the amount of its rigidity. Ruysch (from whom the art of injecting has been called the Ruyschian art,) recommends a previous maceration for a day or two in cold water.

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When the size and the subject have both been properly pre-
pared, have the injection as hot as the finger can well bear.
One of the pipes, G, Fig. 43, must then be placed in the
largest artery of the part, and securely tied.   Put the stop-
cock, F, into the open end of the pipe, and it is then ready to
receive the injection from successive applications of the syringe,
A.   The injection should be thrown in by a very steady and
gentle pressure on the end of the piston-rod.   The resistance
of the vessels, when nearly full, is often considerable, but it
must not be overcome by violent pressure with the syringe.
When as much injection is passed as may be thought advisa-
ble, the preparation may be left (with the stop-cock closed in
the pipe) for twenty-four hours, when more material may be
thrown in.

As the method of injecting the minute capillaries with
coloured size is often attended with doubtful success, various
other plans have been proposed.   Ruysch's method, according
to Rigerius, was to employ melted tallow, coloured with ver-
milion, to which, in the summer, a little white wax was
added.

Mr. Rauby's material, as published by Dr. Hales, was resin
and tallow, of each two ounces, melted and strained through
linen; to which was added three ounces of vermilion, or finely
ground indigo, which was first well rubbed with eight ounces
of turpentine varnish.

Dr. Monro recommended coloured oil of turpentine for the
small vessels, after the use of which he threw in the common
coarse injection.

Professor Breschet frequently employed with success milk,
isinglass, the alcoholic solution of gum-lac, spirit varnish, and
spirit of turpentine; but he highly commends the colouring
matter extracted from campeachy, fernambone, or sandal
woods.   He says, "The colouring matter of campeachy wood

easily dissolves in water and in alcohol; it is so penetrating that it becomes rapidly spread through the vascular networks. The sole inconvenience of this kind of injection is, that it cannot be made to distend any except most delicate vessels, and that its ready penetration does not admit of distinguishing between arteries, veins, and lymphatics." He also recommends a solution of caoutchouc.

Another process, which may be termed the chemical process, was published in the *Comptes Rendus*, 1841, as the invention of M. Doyere. According to this, an aqueous solution of bichromate of potass is propelled into the vessels; and after a short time, in the same manner and into the same vessels an aqueous solution of acetate of lead is injected. This is an excellent method, as the material is quite fluid, and the precipitation of the chromate of lead, which takes place in the vessels themselves, gives a fine sulphur-yellow colour.

Dr. Goadby has improved upon the process last named by uniting to the chemical solutions a portion of gelatine. The following is his formula, originally published in the London Lancet, and again in the Medical Examiner, March, 1850.

Saturated solution of bichromate of potash, 8 fluid ounces; water, 8 ounces; gelatine, 2 ounces.

Saturated solution of acetate of lead, 8 fluid ounces; water, 8 ounces; gelatine, 2 ounces.

Dr. G. gives the following remarks respecting this process: —" The majority of preparations, thus injected, require to be dried, and mounted in Canada balsam. Each preparation, when placed on a slip of glass, will necessarily possess more or less of the coloured infiltrated gelatine, (by which, he alludes to the gelatine, coloured by the blood, which, together with the acetate of potash resulting from the chemical decomposition, may have transuded through the coats of the vessel,) which, when dry, forms, together with the different shades of

the chromate of lead, beautiful objects, possessing depth and richness of colour. The gelatine also separates and defines the different layers of vessels. By this injection the arteries are always readily distinguishable by the purity and brightness of the chromate of lead within them, while the veins are detected by the altered colour imparted by the blood.

"Those preparations which require to be kept wet, can be preserved perfectly in my B fluid—specific gravity 1·100; the A fluid destroys them.

" I would recommend, that the slips of glass employed for the dry preparation be instantly inscribed with the name of the preparation, written with a diamond, for, when dry, it is very difficult to recognise one preparation from another, until the operator's eye be educated to the effects of this chemico-gelatinous injection. Where so much wet abounds gummed paper is apt to come off.

" When dry, it is sufficient for the purpose of brief examination by the microscope, to wet the surface of a preparation with clean oil of turpentine ; immediately after examination, it should be put away carefully in a box, to keep it from the dust, until it can be mounted in Canada balsam.

" The bichromate of potash is greatly superior in colour to the chromate, which yields too pale a yellow; and subsequent experience has convinced me that the acetate of potash frequently effects its liberation by destruction of the capillaries, and this, even long after the preparations have been mounted in Canada balsam; perhaps this may be owing to some chemical action of the acetate of potash upon them.

" I would suggest the substitution of the *nitrate* for the *acetate* of lead, as we should then have, in the liberated nitrate of potash, a valuable auxiliary in the process of preservation.

"Although highly desirable, as the demonstrator of the

capillaries of *normal* tissues, I do not think this kind of injection fitted for morbid preparations, the infiltrated gelatine producing appearances of a puzzling kind, and calculated to mislead the pathologist.

" In preparing portions of dried, well-injected skin, for examination by the microscope, I have tried the effect of dilute nitric acid, as a corroder, with very good results. But, probably, liquor potassæ would have answered this purpose better.

" When size injection is to be employed, coloured either with vermilion or the chromate of lead, the animal should be previously prepared by bleeding, to empty the vessels : for if they be filled with coagulated blood, it is quite impossible to transmit even size, to say nothing of the colouring matter. Hence the difficulty of procuring good injections of the human subject.

" But with the 'chemico-gelatinous' injections no such preparation is necessary; and success should always be certain, for the potash liquefies the blood, while constant and long-continued pressure by the syringe drives it through the parietes of the vessel into the cellular tissue. The large quantity of infiltrated blood—the invariable concomitant of my process— characterizes this from all other modes of injecting, and is a distinctive feature of these preparations."

Still another plan has been suggested (as I am informed) by Dr. Goddard of Philadelphia. It consists in adding a quantity of sulphuric ether to the finely levigated colouring matter, which is also first ground or mixed with linseed oil, in the manner employed by painters. Upon this plan (as well as upon the last named) I have succeeded in making some beautiful injections of the smallest capillaries, yet I have sometimes failed, owing to the too rapid evaporation of the ether, and the clogging up of the vessels from the early deposition of the solid colouring matter. Perhaps a solution of gum mas-

tich, &c., in ether, coloured with fine vermilion, &c., will answer
the indications better.

A fœtus may be injected by the umbilical vein; a uterus,
by the hypogastric arteries; the head, by the carotids; the
liver, mucous membrane of the intestines, &c., by the portal
vein; an extremity, by the principal artery; &c.

Many parts, after injection, require to be macerated in water,
or corroded by dilute muriatic acid, &c., in order to exhibit the
ramifications of the small vessels. They should be very care-
fully handled, or moved, in the macerating liquor, as the slight-
est force may break the vessels. When corroded, the pulpy
flesh is to be carefully washed away by placing it under a
stream of water, flowing very slowly; or by the use of a syringe
with water.

The lymphatics are usually injected with quicksilver, but
M. Rusconi and Professor Breschet, have abandoned this me-
thod for the coloured material, on account of the mercury fre-
quently rupturing by its weight the thin, lymphatic vessels
and reservoirs. The first-named gentleman, in his researches
on the lymphatics of reptiles, employs in place of the usual
injecting tube of Walter (used with the mercury), a small
silver syringe, together with a kind of trocar, of which the
canula is formed from the quill of the wing-feather of the quail
or partridge, the trocar being a tolerably large-sized needle,
the point of which has three facets. When desirous of in-
jecting the lymphatic system of a lizard, tortoise, &c., he re-
marks:—" I seize with a small pair of forceps the mesentery,
close to the vertebral column, where the reservoir of the chyle
is situated, and I introduce into it the point of the trocar; I
then retain the quill and withdraw the needle from the tube.
This done, I seize with the small forceps the quill, and intro-
duce into it the small extremity of the syringe, and push the
piston with a force always decreasing." He recommends
coloured wax, mixed with nut-oil, for the injection.

CHAPTER XII.

THE chemical composition of the urine and urinary deposits has within a few years past attracted much attention, and has contributed much to our knowledge respecting the nature of diseases and their diagnosis. To examine these, the microscope is often an essential instrument.

Deposits of *uric acid* and its combinations (called red, or yellow-sand sediments), occur in fever; in acute inflammation; in rheumatism; in phthisis; in all the grades of dyspepsia; in all or most stages of diseases attended with arrest of per-spiration; in diseases of the genital apparatus; from blows and strains of the loins; from excessive indulgence in animal food; or from too little exercise.

The deposition of *earthy phosphates* (white deposit), should be regarded as of serious importance, always indicating the existence of important functional, and frequently of organic disorder. According to Dr. Bird, they always exist simul-taneously with a depressed state of nervous energy, often general, rarely more local, in its seat.

Deposits of oxalate of lime are regarded by Dr. G. Bird as by no means so rare as is generally supposed. He believes that it owes its origin to sugar, and is caused by derangement of the digestive organs.

The urine may contain all or any of the elements of the

blood. The serum may be effused alone, or be accompanied with the red globules.

Whenever the elements of blood appear in the urine, there is ample proof of the existence of active or passive hemorrhage of the kidneys, or urinary tract.

Albuminous urine occurs in Bright's disease, dropsy after scarlatina, &c.

Pus is met with in the urine as the result of suppuration of the kidney, or of some part of the genito-urinary mucous membrane, or of abscesses of the neighbouring viscera, opening into the urinary passage.

The presence of *sugar* is not uncommon in dyspepsia, and when excessive is diagnostic of diabetes mellitus.

Kiestein is a whitish, greasy, opalescent pellicle, sometimes found on the urine of pregnant women.

To examine urinary deposits with the microscope, allow the urine to stand; decant the supernatant fluid; pour the remainder into a watch-glass; draw off the small quantity of fluid remaining after a short repose, by means of a pipette; and then place it on the stage of the microscope. When, however, it is necessary to use high powers, a drop of the sediment should be placed on a glass slide and covered with thin glass.

If it is desired to mount the object for future examination, it can be covered, when dry, with a drop of Canada balsam, and surmounted with the thin glass. Very transparent objects should be kept in fluid, as weak spirit, water saturated with creasote, or Goadby's fluid.

HEALTHY URINE holds in solution a variety of substances, both organic and inorganic. Chemists have not yet succeeded in insulating all its ingredients for examination, but the most important of its solid materials are urea, uric acid, hippuric acid, vesical mucus and epithelial debris, animal extractive, ammoniacal salts, fixed alkaline salts, and earthy salts.

The amount passed by an individual during each twenty-four hours, varies from twenty to fifty ounces, holding in solution from six hundred to seven hundred grains of solid matter. When kept for some time it gradually becomes turbid, and deposits a sediment of earthy phosphates, previously held in solution by the slight excess of acid present. If kept still longer, it gradually putrefies, and, becoming concentrated by evaporation, deposits small crystals of chloride of sodium, phosphates, and other salts, and eventually becomes covered with a grayish-coloured mould.

Urea appears to be the vehicle by which nearly the whole of the nitrogen of the exhausted tissues of the body is removed from the system. The proportion of urea in healthy urine averages fourteen or fifteen parts in the one thousand. Pure urea may be obtained by first converting it into the oxalate, which is done by adding a strong solution of oxalic acid in hot water, to urine previously concentrated to about one-eighth its bulk, and filtered to free it from the insoluble sediments of phosphates and urates. The crystals of oxalate of urea thus obtained, *a*, Fig. 44, should be dissolved in hot water, and the solution treated with pulverized chalk as long as effervescence is produced. The urea remains in solution, and may be purified by boiling with animal charcoal, after which it may be crystallized, in four-sided prisms, by careful evaporation.

Nitrate of urea may be obtained in crystals, *b*, Fig. 44, by concentrating urine to about one-half its bulk, and adding an equal quantity of nitric acid. If urea be suspected in excess, a drop of the urine, without concentration, may be treated with nitric acid under the microscope.

The proportion of *uric acid* in the healthy secretion varies from 0·3 to 1·0 in 1000 parts. Its forms will be represented when we treat of the examination of urinary deposits. It may be obtained from urine concentrated to half its bulk, by adding

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a few drops of hydrochloric acid, and allowing it to stand a few hours in a cool place.

Fig. 44.
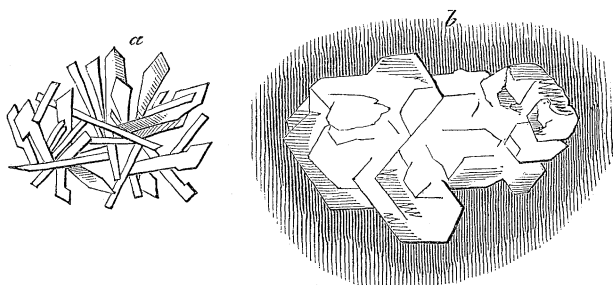
Hippuric Acid is generally present in a small quantity in healthy urine, and in certain forms of disease, especially where a vegetable diet has been adopted. Fig. 45 represents some

Fig. 45.
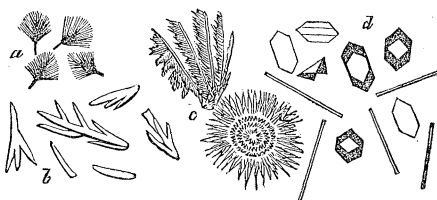
of its forms; *a* are deposited from an alcoholic solution, and *b* from a hot aqueous solution.

When an excess is suspected in urine, it should be evaporated to the consistence of syrup and mixed with half its bulk of strong hydrochloric acid. After a few hours the crystals

may be examined with the microscope, when the tufts will probably be seen, coloured pink by the admixture of purpurine.   If it be present only in small quantity, a few detached needle-like or branched crystals may be seen.   It is readily soluble in alcohol and hot water, but not in cold water.

Vesical Mucus and *Epithelial Scales*, which may be present, are derived from the internal surface of the bladder and urinary passages.   The quantity is so small in healthy urine as to be scarcely visible, until, after standing, it has subsided to the bottom of the liquid in the form of a thin cloud.

Extractive Matter, includes all the uncrystallizable organic matter found in the residue of evaporated urine, which is soluble in water or alcohol.   When in excess, the urine appears more highly coloured than usual, a large proportion of what is termed extractive, consisting of colouring matter, as purpurine, &c.

Ammoniacal Salts appear to consist chiefly of the muriate and the urate, the latter salt being the form in which the uric acid present in the urine appears to be held in solution.

The proportion of ammonia in healthy urine is quite small, but in some diseases, especially in certain kinds of fever, it increases considerably.

Fixed Alkaline Salts may be obtained by incinerating the evaporated residue of urine, when a white ash will be left, consisting of a mixture of alkaline and earthy salts ; the former may be separated from the latter by dissolving in water, in which the earthy salts are insoluble.

The alkaline salts, which in the healthy secretion usually amount to thirteen or fourteen parts in one thousand, consist of the sulphates of potash and soda, chloride of sodium, chloride of potassium, and phosphate of soda.   The crystallized residue, after slowly evaporating a few drops on a piece of glass, usually has the appearance represented in Fig. 46.   The cross-

lets consist of chloride of sodium; the more plumose crystals are probably phosphate of soda.

Fig. 46.
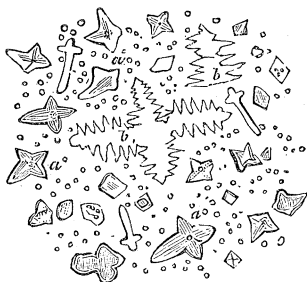
The Earthy Salts which form the insoluble portion of the ash, and which usually amount in healthy urine to about 1 part in 1000, consist of the phosphates of lime and magnesia, together with a small trace of silica. These appear to be retained in solution in the urine by the small excess of acid (probably phosphoric) usually present, and may be precipitated from it by supersaturating with ammonia. The precipitate thus formed consists of a mixture of phosphate of lime, and the double phosphate of ammonia and magnesia, which is also called triple phosphate. These, with the abnormal ingredients found in morbid urine, &c., will be treated of when we come to the examination of urinary deposits. It must be borne in mind, however, that a spontaneous precipitate of earthy phosphates is not of itself a proof that they are present in excess, for when the urine is acid, as in health, a considerable quantity may be retained in solution, while if it be neutral or alkaline, a comparatively small proportion may be precipitated.

When urinary deposit is examined with the microscope, it

will be found either *crystalline, amorphous,* or *organized.*
When, as is frequently the case, the deposit consists of a
mixture of different forms, each of them in succession should
be examined, until the nature of the whole deposit is clearly
understood.

CRYSTALLINE DEPOSITS, will probably be either uric acid,
phosphate of lime and magnesia (from which the triple phos-
phate is formed), oxalate of lime, or perhaps cystine.

Triple Phosphate.—This salt (called also the double phos-
phate of ammonia and magnesia) is formed by supersaturating
with ammonia.   Phosphate of lime is also precipitated by the
same means, but may be distinguished by the microscope.
The crystals of the triple phosphate are stellate or triangular
prisms, as seen in Fig. 47.   They disappear on the addition of
acetic acid.

Uric (or *Lithic*) *Acid.*—This salt, like the earthy phos-
phates, exists in a small quantity in healthy urine, but as the
proportion varies considerably in many forms of disease, its
determination when in abnormal quantity, affords much assis-
tance in diagnosis.

It is insoluble in alcohol, and nearly so in dilute hydro-
chloric and sulphuric acid; but it combines with the alkalies,
forming salts, which are insoluble or very sparingly soluble in
water.

The action of nitric acid upon uric acid is characteristic.   It
will gradually dissolve it, carbonic acid and nitrogen being
given off with effervescence, leaving behind a mixture of
alloxan ($C_8 N_2 H_4 O_{10}$), alloxantine ($C_4 H_3 N_2 O_3$), and other
compounds.   This may be evaporated nearly to dryness, when
a red residue will be left, which, when cold, should be moist-
ened with ammonia, which will develope a beautiful purple
colour, owing to the formation of murexide ($C_{12} N_5 H_6 O_8$).

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The crystalline forms of uric acid are various, but appear to be modifications of the rhombic prism.

Fig. 47.
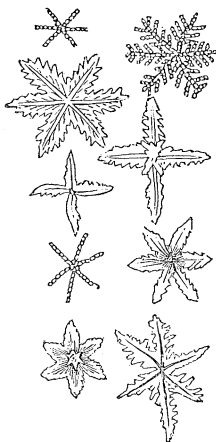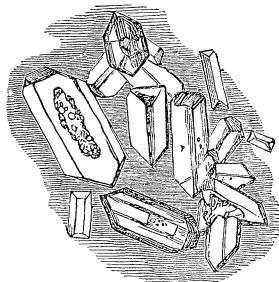
Fig. 48 represents some of its forms.

Oxalate of Lime often exists in the form of minute octahedral crystals, varying from $\frac{1}{750}$th to $\frac{1}{3600}$th of an inch in diameter, a, Fig. 49. When allowed to dry on the glass, each

crystal appears under the microscope like a black cube, having

Fig. 48.
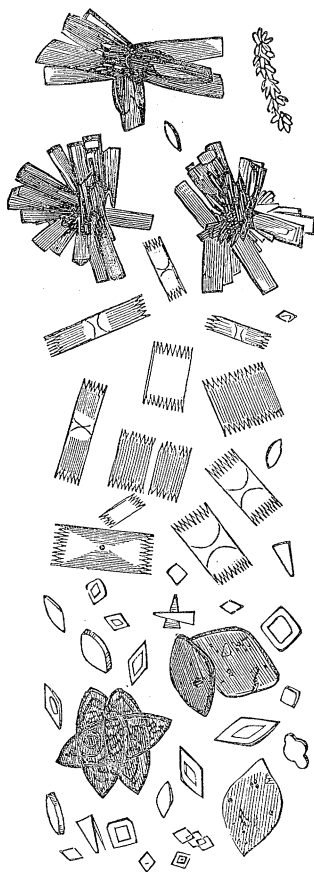
in the centre a small white square opening, as shown at *b*.

This is owing to the rays of light being mostly refracted be-
yond the field of vision.   On again moistening them, the crys-
tals reappear in their octahedral form.   Sometimes this salt

Fig. 49.
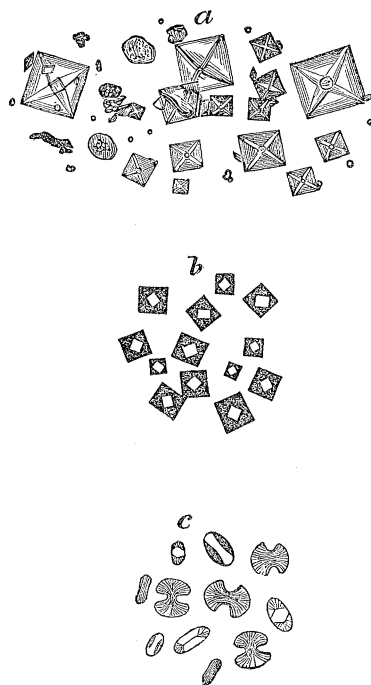
assumes the forms represented at *c*, more or less resembling
dumb-bells.*   This form, like the crystals of uric acid, the

* Dr. Fricke, in the American Journal of Medical Science, July,
1850, states as his opinion that the dumb-bell forms of crystals are
not oxalate of lime, but disintegrated crystals of uric acid.

triple phosphate, &c., is beautifully coloured when examined by polarized light; the octahedral variety has little or no effect upon it, being invisible, or nearly so, when the field is dark. If the "dumb-bells" are kept in liquid for any length of time, they gradually pass into octahedra.

As the crystals of oxalate of lime are very transparent, and about the same specific gravity as the urine, they may readily escape detection, unless some considerable time is allowed for deposition, or the urine is passed through a filter.

Oxalate of lime is insoluble in water, in acetic and oxalic acids, and in solution of potash; but it is readily soluble in dilute nitric and hydrochloric acids.

Cystine has occasionally been found as a crystalline deposit and in the form of small calculi.   It may be distinguished by being insoluble, or nearly so, in water and dilute acids, but soluble in ammonia, from which small hexagonal crystals are deposited on evaporation.   The usual microscopic appearance is represented at *a*, Fig. 50.   At *b* is the form left from the ammoniacal solution.

Fig. 50.
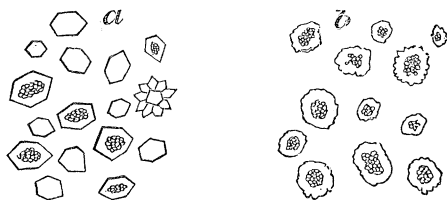
AMORPHOUS DEPOSITS consist probably of phosphate of lime, urate of ammonia, urate of soda, fat, or chylous matter.

Phosphate of Lime.—This salt has already been described as existing in urine in conjunction with the phosphate of magnesia.   It is thrown down, together with the triple phosphate

(before noticed), on the addition of ammonia. The crystalline shape of the triple phosphate, however, readily distinguishes it under the microscope from the amorphous particles of phosphate of lime with which it is usually mixed. The earthy phosphates are readily soluble in dilute acids, from which they are precipitated by ammonia. They are insoluble in a solution of potash.

Urate of Ammonia constitutes one of the most common urinary deposits. It is gradually deposited as the urine cools, in the form of an amorphous precipitate, which, with a high magnifying power, appears to consist of minute rounded particles, occasionally adhering together, frequently mixed with small crystals of uric acid, and occasionally with the earthy phosphates. A deposit of urate of ammonia readily dissolves when the urine containing it is gently warmed, and is precipitated again when the liquid cools. (The earthy phosphates and uric acid are nearly as insoluble in hot as cold water.)

When urate of ammonia is treated with dilute acetic or hydrochloric acid, it is decomposed, and uric acid is formed.

Urate of Soda is often met with in the urine of patients taking medicinally the carbonate or other salts of soda. It resembles the urate of ammonia in being soluble in hot water, and in most of its chemical characters, but may be generally recognised without difficulty under the microscope, forming minute globular or granular aggregations, with, occasionally, irregular and curved protuberances.

Fat may be recognised by the particles being minute round globules, with dark and well-defined outlines, which dissolve when agitated with ether.

Sometimes this substance is mixed with albuminous matter, forming a kind of emulsion, so that no trace of fat can be perceived with the microscope. In such cases, the urine may be agitated with a little ether, which will dissolve the fat, and

the solution so formed will separate from the watery liquid, and form a distinct stratum on the surface.

Chylous Matter may be known by the urine being opaque and milky in appearance, yielding fatty matter when agitated with ether, and containing minute, amorphous, albuminous particles, and perhaps also colourless globules, which may possibly be mistaken for oil globules, from which their insolubility in ether distinguishes them.

ORGANIZED DEPOSITS may either be mucus, usually mixed with epithelium ; pus ; blood ; or semen.

Mucus.—If the particles observed with the microscope are round, or nearly so, and granulated on the surface, entangled in tenacious, stringy masses, which do not break up and mix uniformly with the liquid on agitation, it is probably mucus.

Epithelial debris may be recognised by the peculiar form of its particles.   Mucous urine generally contains a considerable amount of earthy phosphates and other matters.

Pus may be known by the particles not being held together by any tenacious matter, but floating freely in the liquid.   The granules of pus and mucus present almost the same appearance under the microscope, although the latter may probably be rather smaller and less distinctly granular.   Acetic acid renders the interior nuclei visible in both, but it coagulates the fluid portion of the mucus.

Even this test may be uncertain, on account of the dilution of the mucous fluid, and also because the coagulation may have been already occasioned by the presence of the large quantity of water.   When the quantity of mucus is abundant, however, this test will be sufficient.

Blood.—When this is suspected in the urine, it may be examined under the microscope for any blood corpuscles that may be in it.   If the blood has coagulated, they will probably be entangled in the coagula, and may be forced out by

gentle pressure under a strip of thin glass. If there is no coagula, the liquid may rest for a short time, and a drop from the bottom examined. The urine may also be tested for albumen after separating the solid matter by filtering. When the colouring matter of the blood is present, it will coagulate with the albumen, giving it a red or brown colour. When the fibrin, in its soluble form, is present, it usually coagulates spontaneously on cooling, causing the urine to become gelatinous. The coagulum of fibrin, when pressed between glasses, is generally composed of minute amorphous particles, with a few red blood corpuscles, quite different from the granular mucus corpuscles, for which it might be mistaken without microscopic examination.

Bile or purpurine in urine has nearly the same colour as when blood is present; hence, unless the blood corpuscles are present, we should apply the tests for the detection of those substances before finally deciding. Purpurine will be dissolved by treating with warm alcohol, or may be precipitated by adding a little warm aqueous solution of urate of ammonia, which on cooling will fall down, carrying with it the colouring matter. Bile may be tested by pouring a few drops of urine on a white plate, and adding carefully a drop or two of nitric acid. When bile is present in any considerable quantity, the liquid becomes successively pale-green, violet, pink, and yellow, the colour rapidly changing as the acid mixes with the urine. When only slight traces of bile are present, the urine should be concentrated by evaporation.

When *semen* is present in urine, it may easily be detected under the microscope, by the appearance of minute animalcules, always found in the spermatic fluid, and hence called spermatozoa. They are oval in shape, with long and delicate tails. Traces of albumen may generally be detected in urine containing semen.

DIABETIC AND ALBUMINOUS URINE.—*Albumen* may be tested by boiling the suspected urine gently in a test-tube, when it will be coagulated. As, however, a white precipitate results on boiling, from an excess of earthy phosphates, it will be necessary to add a few drops of nitric acid, which will re-dissolve the phosphates but leave the coagulated albumen un-affected. Nitric acid also will coagulate albumen. If both heat and nitric acid throw down a white precipitate from urine in separate portions, there can be no doubt of the presence of albumen.

The peculiar casts of urinary tubes found in the urine of patients suffering from Bright's disease, consist of fibrinous or albuminous matter and entangling blood-corpuscles, epithelium, and fatty globules.

Diabetic Sugar has the same chemical composition as that contained in most kinds of fruit, known as grape sugar. Several tests have been proposed for its detection in urine.

Trommer's Test is founded on the circumstance that when a solution of diabetic or grape sugar is boiled with a mixture of potash and sulphate of copper, the oxide of copper contained in the latter is reduced to the state of suboxide, which is pre-cipitated in the form of a reddish-brown or ochre-coloured granular powder.

Moore's Test is made by mixing a little suspected urine with half its volume of liquor potassæ and boiling gently for about five minutes. If sugar is present, the liquid assumes a brown or bistre tint.

The Fermentation Test is made by filling a test-tube with the suspected urine, to which a little yeast has been added. The tube is then inverted over a saucer containing some of the urine, and set aside in a warm place for about twenty-four hours. If sugar is present it undergoes the vinous fermenta-tion by which it becomes converted into alcohol and carbonic

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acid. The latter rises in the tube and displaces the liquid. If no sugar be present, no fermentation will take place, and no gas will be formed in the tube.

Test from the Growth of the Torula.—During the process of the vinous fermentation of a liquid containing sugar, a delicate white scum collects on the surface, which when examined with a magnifying power of four or five hundred diameters, will be found to consist of small, oval vesicles, *a*, Fig. 51, which, in

Fig. 51.

b   *a*
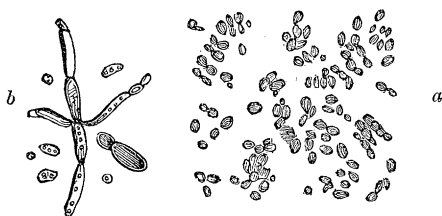
the course of a few hours, rapidly change their form, becoming longer and more tubular, and give rise to new vesicles, which shoot out from the parent body, forming an irregular jointed confervoid stem, *b*. These again break up into a great number of oval vesicles, which separate, and fall to the bottom, where they may be detected by the microscope.

The following tables for facilitating the examination of urine and urinary deposits, are modified from Bowman's Medical Chemistry. The reader may also consult the Manuals of Drs. Golding Bird, Griffith, Markwick, and Rees. The works of the latter three gentlemen have been published in Philadelphia, in one convenient volume. The "Analysis" of Dr. Rees contains also a valuable essay on the treatment of urinary diseases.

TABLE I.

FOR THE CHEMICAL EXAMINATION OF URINARY DEPOSITS.

1. The sediment dissolves when warmed. *Urate of Ammonia.*

2. Not soluble when warmed, but soluble in acetic acid. *Earthy Phosphates.*

3. Insoluble in acetic, but soluble in dilute hydrochloric acid. *Oxalate of Lime.*

4. Insoluble in dilute hydrochloric acid. Purple with nitric acid and ammonia. *Uric Acid.*

If neither of these, it may be,

5. Greenish-yellow deposit, easily diffused on agitation. *Pus?*

6. Ropy and tenacious. *Mucus?*

7. Red or brown; not soluble when warmed; the fluid portion coagulable by heat and nitric acid. *Blood?*

8. Soluble in ammonia; the solution leaving, on evaporation, hexagonal crystals. *Cystine?*

9. Yellowish sediment, soluble when warmed. *Urate of Soda?*

10. Ether yields, after agitation, an oily or fatty residue. *Fatty Matter.*

11. Milky appearance. *Chylous Matter.*

TABLE II.

FOR THE EXAMINATION OF THE CLEAR LIQUID PORTION.

1. Crystals with nitric acid. *Excess of Urea.*

2. Fermentation, or Trommer's test. *Sugar.*

3. Precipitate formed on boiling; soluble in nitric acid. *Excess of Earthy Phosphates.*

4. Precipitate formed on boiling; insoluble in nitric acid. *Albumen.*

5. Precipitate formed by nitric acid. *Excess of Uric Acid,* or *Albumen.*

6. Concentrated urine yields needle-shaped crystals with hydrochloric acid. *Hippuric Acid.*

If the urine is highly coloured,

7. Dark coagulum formed on boiling. *Blood?*

8. Red colour with hydrochloric acid. *Excess of Colouring Matter.*

9. Pink precipitate with warm solution of urate of ammonia. *Purpurine.*

10. Change of colour with nitric acid. *Biliary Matter.*

TABLE III.

FOR MICROSCOPIC EXAMINATION OF DEPOSIT.

If Crystalline.

1. Lozenge-shaped, &c. *Uric Acid.*

2. Stellæ, or three-sided prisms (after saturating with ammonia). *Triple Phosphate.*

3. Octahedra, or dumb-bells. *Oxalate of Lime.*

4. Rosette-like tables. *Cystine.*

If Amorphous.

5. Soluble when warmed. *Urate of Ammonia.*

6. Soluble in acetic acid. *Phosphate of Lime.*

7. Yellowish grains. *Urate of Soda?*

8. Round globules with dark edges.   *Fatty Matter.*
9. White and milky.   *Chylous Matter?*

If Organized.

10. Granulated corpuscles, in stringy aggregations.   *Mucus.*
11. Irregularly shaped scales.   *Epithelium.*
12. Detached granulated corpuscles.   *Pus.*
13. Blood-corpuscles.   *Blood.*
14. Spermatozoa.   *Semen.*

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CHAPTER XIII.

ON POLARIZED LIGHT.

"If we transmit," says Dr. Brewster, "a beam of the sun's light through a circular aperture into a dark room, and if we reflect it from any crystallized or uncrystallized body, or transmit it through a thin plate of either of them, it will be reflected and transmitted in the very same manner and with the same intensity, whether the surface of the body is held above or below the beam, or on the right side or left, or on any other side of it, provided that in all these cases it falls upon the surface in the same manner, or, what amounts to the same thing, the beam of solar light has the same properties on all its sides; and this is true, whether it is white light as directly emitted from the sun, or whether it is red light, or light of any other colour.

"The same property belongs to light emitted from a candle,

Fig. 52.
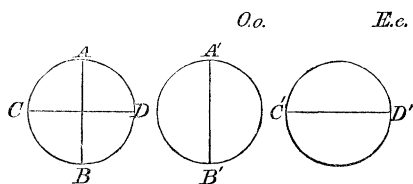
or any burning or self-luminous body, and all such light is called *common* light. A section of such a beam of light will

be a circle, like A, B, C, D, Fig. 52, and we shall distinguish the section of a beam of common light by a circle with two diameters, AB, CD, at right angles to each other.

"If we now allow the same beam of light to fall upon a rhomb of Iceland spar, as in Fig. 53, and examine the two

Fig. 53.
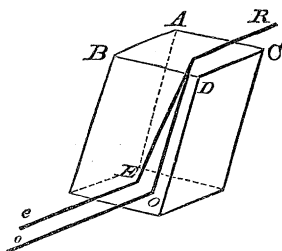
circular beams, O o, E e, formed by double refraction, we shall find,

"1. That the beams O o, E e, have different properties on different sides; so that each of them differs, in this respect, from the beam of common light.

"2. That the beam O o differs from E e in nothing, excepting that the former has the same properties at the sides A' and B' that the latter has at the sides C' and D', as shown in Fig. 52; or, in general, that the diameters of the beam, at the extremities of which the beam has similar properties, are at right angles to each other.

"These two beams, O o, E e, Fig. 53, are therefore said to be *polarized*, or to be beams of *polarized* light, because they have sides or *poles* of different properties.

"Now it is a curious fact, that if we cause the two polarized beams, O o, E e, Fig. 53, to be united into one, we obtain a beam which has exactly the same properties as the beam A, B, C, D, Fig. 52, of common light. Hence we infer, that a beam

of common light consists of *two* beams of polarized light, whose planes of polarization, or whose diameters of similar properties, are at right angles to one another."

There are other means of polarizing light besides that of double refraction, just mentioned.   M. Malus discovered, in 1810, that a beam of common light, reflected from glass at an angle of 56°, or from water at an angle of 53° became polarized.

In order to explain the phenomena of polarized light when produced by reflection from glass, let C, D, Fig. 54, represent

Fig. 54.
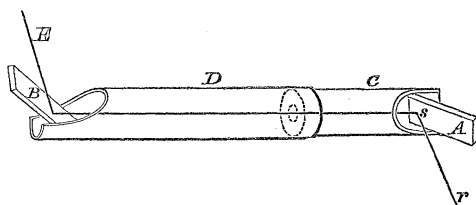
two tubes, one turning within the other.   A, B, are plates of glass capable of turning on their axis, so as to form different angles with the axis of the tube.

If a beam of light, *r s*, from a candle or hole in the window-shutter, fall upon A at the polarizing angle of 56° 45′, it will be reflected through the tubes, and will fall upon the second plate, B, also at an angle of 56° 45′.   If, however, this plate be so placed that its plane of reflection is at right angles to the plane of reflection of the first plate, A, the ray of light *will not suffer reflection* from B, or will be so faint as to be scarcely visible.   If we now turn round the tube, D, carrying the plate, B, without moving the tube, C, the reflected ray, E, will become brighter and brighter till the tube has been turned round 90°, when the plane of reflection from B is coincident with

or parallel to that from A. In this position the reflected ray, E, is brightest. If the tube be turned again, the light will grow more and more faint, until another 90° are arrived at, when it will again undergo reflection. Thus, changes will take place in every quadrant of 90° until the starting-point is again reached, the ray of light being alternately faint and visible.

The same effect will be produced if we cause a ray of light, R, Fig. 55, to pass through bundles of glass plates, A, B, in-

Fig. 55.
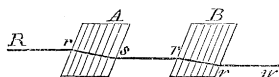
clined at the proper angle. If the bundle of plates, B, be placed as in the figure, the ray, *s t*, polarized by passing through the bundle, A, will be incident on B at the polarizing angle, and not a particle will be reflected, but it will be transmitted, as seen at *v w*. If B is now turned round its axis, the transmitted light, *v w*, will gradually diminish, and more and more light will be reflected by the plates of B, till, after a rotation of 90°, the ray, *v w*, will disappear, and all the light will be reflected. Alternate transmissions and reflections will thus take place in each quadrant, as in the former case. For the ray passing through the tube in Fig. 54, or the ray, *s t*, in the last figure, we may substitute one of the polarized rays formed by double refraction in a rhomb of Iceland spar, as seen in Fig. 53, or we may employ with even greater advantage the *single image prism* of Mr. Nicol, who employed a rhomb of calcareous spar divided into two equal portions, in a plane passing through the acute lateral angles, and nearly touching the obtuse solid angles. The cut surfaces having been carefully polished, were then cemented together with Canada

balsam, so as to form a rhomb of nearly the same size and shape as it was before cutting.

By this arrangement, of the two rays into which a beam of common light would be separated, only one is transmitted, the other being rendered too divergent. Two of these prisms form the usual polarizing apparatus of the microscope, being used in the same manner as the bundles of glass plates, Fig. 55, just described. One of the prisms is adapted to the under surface of the stage, and is called the *polarizer;* the other, called the *analyzer,* is placed above the eye-glass.

Dr. Brewster recommends that the analyzing prism be placed immediately behind the object-glass, next the eye, having a rotation independent of the body of the microscope.

Another method of polarizing light, is to disperse or absorb one of the oppositely-polarized beams which constitute common light, and leave the other beam polarized in one plane. These effects may be produced by thin plates of agate, tourmaline, &c.

Many persons employ a thin plate of tourmaline as an *analyzer* in place of a Nicol's prism, and if its colour be not objectionable, it may be used to advantage, as the field of view is not so much contracted as when a prism is used.   A tourmaline of a neutral tint is an excellent analyzer.

The splendid colours, and systems of coloured rings, produced by transmitting polarized light through transparent bodies that possess double refraction, are the most brilliant phenomena that can be exhibited. They were discovered simultaneously by M. Arago and Dr. Brewster.

To see these colours:—having the polarizing apparatus so placed that no light can be seen through it, place a thin film of mica or sulphate of lime (between the twentieth and fiftieth of an inch thick), so that the polarized beam may pass through it perpendicularly.   It should be placed between the *polarizer*

and the *analyzer*, as on the stage of the microscope. If now the eye is applied to the polarizing apparatus, as before, the surface of the film of sulphate of lime, &c., will be seen covered with the most brilliant colours. If the film be turned round, still keeping it perpendicular to the polarized ray, the colours will become less or more bright, and two positions will be found, at right angles with each other, wherein no colours at all are perceived. If the analyzer be turned round, the film retaining its position, complementary colours will alternate, together with points of invisibility, during each revolution.

The colours of the film vary with its thickness, so that by making grooves or lines of various depths, the most beautiful patterns may be produced. Drawings of figures and land-scapes are thus executed, and being mounted between glasses in Canada balsam, are invisible, or nearly so, till exposed to polarized light, when they are seen distinctly, arrayed in most gorgeous colours.

Various crystals exhibit, round their axes of double refrac-tion, beautiful systems of coloured rings, often intersected by a black cross. Complementary colours may be produced in them by turning round the analyzer. In large crystals, as rhombs of Iceland spar, certain angles must be ground down and polished in order to exhibit the rings.

In those crystals having two axes of double refraction, a double system of rings will be seen. A transverse section of a prism of nitre will exhibit this phenomenon.

The great advantage of employing the microscope in viewing the colours of crystals, &c., by polarized light, arises from the fact that, when crystallized on a slip of glass, many of the small crystals will be arranged with their axes of double re-fraction in the direction of the polarized beam. All such, therefore, will exhibit colours, as will those also in which the thickness of the crystal is not below the proper standard.

After the polarizing apparatus is adjusted, as before described, the crystals, properly mounted, may be placed on the stage, in the same way as ordinary objects. Some few vegetable structures may be exhibited in the same manner, as the siliceous cuticle of equisetum, starch, &c. Many animal structures, as feathers, slices of quill, horn, &c., are best shown by placing a film of selenite or mica beneath them, by which they become intensely coloured. If the film be of unequal thickness, the colours will vary.

"The application," says Mr. Quekett, " of this modification of light to the illumination of very minute structures has not yet been fully carried out, but still there is no test of differences in density between any two or more parts of the same substance that can at all approach it in delicacy. All structures, therefore, belonging either to the animal, vegetable, or mineral kingdom, in which the power of unequal or double refraction is suspected to be present, are those that should especially be investigated by polarized light. Some of the most delicate of the elementary tissues of animals, such as the tubes of nerves, the ultimate fibrillæ of muscle, &c., are amongst some of the most striking subjects that may be studied with advantage under this method of illumination."

To Prepare Crystals for Polarized Light. — Pour a few drops of a saturated solution of the salt on a glass slide gently warm it over a spirit lamp, so as to evaporate the excess of fluid, taking care not to apply too much heat, lest the water of crystallization be driven off and the salt become opaque. The more slowly the crystallization is effected the better.

The crystals should then be examined, and the best of them mounted, either in the dry way (interposing a cell of paper, &c., to preserve them from injury by the pressure of the glass cover), or in Canada balsam. If it be desired to examine the

crystals during their formation, the crystallization should be carried on in a glass that is slightly concave.   All those crystals that are so thin as not to exhibit colour, may have colour given them by placing a film of mica or selenite under them on the stage of the microscope.

According to Mr. Fox Talbot, who first applied the microscope to the examination of polarized light, sulphate of copper, crystallized from a solution to which a little nitric ether has been added; oxalate of chromium and potash, from an aqueous solution; and borax, crystallized in dilute phosphoric acid, are especially beautiful.

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CHAPTER XIV.

MISCELLANEOUS HINTS TO MICROSCOPISTS.

ON CLEANING THE GLASSES.—"When you clean the eye-glasses (a point of great importance to pure vision), do not remove more than one at a time, and be sure to replace it before you begin another; by this means you will be sure to preserve the component glasses in their proper places; recollect that if they become intermingled, they will be useless. Keep a piece of well-dusted chamois leather, slightly impregnated with some of the finest putty or crocus powder, in a little box to wipe them with—for it is of consequence to preserve it from dust and damp; the former will scratch the glasses, and the latter will prevent you from wiping them clean. As to the object-glasses, endeavour to keep them as clean as possible without wiping, and merely use a camel's-hair pencil to brush them with; for wiping them hard with anything has always a tendency to destroy their adjustment, unless they are firmly burnished into their cells."—*Dr. Goring.*

ON STOPPING FALSE LIGHT IN MICROSCOPES.—This is one of the most important requisites in an instrument; for however perfect it may be, if there is the least light reflected from the mountings of the glasses, or within the tubes, the fog and glare produced will materially deteriorate their performance; it is therefore necessary that all their surfaces be made as sombre as possible. The usual method of effecting this is to

cover the parts while hot with a black lacquer, made by mixing lampblack in a solution of shell-lac in strong spirits of wine. A more elegant method, and better suited for delicate work, is to wash the surface, previously freed from grease and tarnish, with a solution of platina in nitro-muriatic acid (chloride of platinum); after remaining on the work a few minutes it is wiped off, the surface having assumed a deep brown or black colour. If these are not at hand, a strong solution of muriate of ammonia will answer for temporary purposes. Another method of stifling false light is by stops or diaphragms in the body of the instrument; these have already been referred to.

CABINET FOR MICROSCOPIC OBJECTS.—The author of " Microscopic Objects" recommends a cabinet with shallow drawers—twelve of them occupy a depth of four and a half inches—the most convenient width from front to back being six inches. Into these shallow drawers the slides containing the objects are laid flat in double rows. The outer ends of the slides are made to fit into a ledge in the front and back of each drawer. The inner ends of the sliders meeting in the middle of the drawer are kept down by a very thin slip of wood covered with velvet. In this way the sliders do not shake when the cabinet is moved from place to place; every object is seen without removal, and no loss of time is occasioned in making a selection.

Some persons have their sliders arranged edgewise, in boxes made in imitation of books; the ends of the sliders being held by a sort of rack. This may sometimes be convenient, but the other form is preferable.

BREWSTER'S METHOD OF ILLUMINATING OBJECTS.—Considering a perfect microscope as consisting of two parts, viz., an illuminating apparatus, and a magnifying apparatus, Sir D. Brewster states, that it is of more consequence that the

illuminating apparatus should be perfect, than that the magnifying one should be so; and the essential part of his method consists in this :—That the rays which form the illuminating image or disc shall have their foci exactly on the part of the microscopic object to be observed, so that the illuminating rays may radiate as it were from the object, as if it were luminous. Now this can only be well attained by illuminating with a single lens, or a system of lenses, without spherical or chromatic aberration, whose focal length, either real or equivalent, is less than the focal length of the object-glass of the microscope. The smaller the focal length of the illuminating lens, or system of lenses, the more completely do we secure the condition that the illuminating rays shall not come to a focus, either before they reached the object, or after they have passed it.

MODE OF OBTAINING THE WHEEL ANIMALCULÆ (*Vorticella rotatoria*).—" Early in the spring I fill a three-gallon jug with pure rain water (not butt-water, because it contains the larvæ of the great tribe). This quantity more than suffices to fill a half-pint mug, and to keep it at the same level during the season. I then tie up a small portion of hay, about the size of the smallest joint of the little finger, trimming it so that it may not occupy too much room in the mug, and place it in the water; or about the same quantity of green sage leaves, also tied and trimmed. About every ten days I remove the decayed portion with a piece of wire, and substitute a fresh supply. A much greater number of animalcules are raised by the sage leaves; but I have sometimes been obliged to discontinue the use of it, on account of its producing mouldiness. I take them out with an ear-picker, scraping up the sides of the mug near the surface (including the dirt which adheres to them by the tail), or under the hay or sage."—*J. Ford.*

SUBSTITUTE FOR THE CONCAVE SPECULUM.—Mr. G. Jackson employs a plano-convex lens of about two inches in diame-

ter, and of four and a half inches focus, silvered on the plane side, and backed with a plate of brass. This lens, when so treated, becomes a reflector of about two and a quarter inches focus, and forms one of the best instruments that can be desired for throwing light upon an object viewed as opaque. We have used such an arrangement for some time in place of the concave mirror, and deemed it peculiar to ourselves till reading an account of the above.

APPARATUS TO PREVENT THE EVAPORATION OF LIQUIDS UNDER THE MICROSCOPE.—Vapours arising from the liquids under observation would, by condensing on the under surface of the object-glass, form there round drops, which act as so many lenses, and which, arresting the rays of light in their progress, would scatter them in every direction, and thus completely destroy the image before it could reach the object-glass. This effect takes place not only when the temperature of the liquid is raised by the application of heat, either directly or in consequence of chemical action, but also when, in studying any body by the microscope, a fuming acid is used, such as the hydrochloric. This inconvenience is prevented by enclosing the frame of the object-glass in a small glass tube, shut at one end, whose inner surface is closely applied to the surface of the object-glass. This end is then plunged into the liquid, which is thus prevented from either beclouding the surface of the lens or finding its way into the interior of the microscope and there producing the same effect.—*Raspail's Organic Chemistry.*

DROPPING TUBES, for placing on the object-holder or slide any reagent whose action is to be examined, may be easily made by softening a piece of glass tube in the flame of a lamp, and drawing it out till it becomes capillary, after which it may be broken to a convenient length. Fishing-tubes for animalculæ may also be made in the same way.

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RESULTS OF DR. GRUBY'S OBSERVATIONS ON PATHOLOGICAL MORPHOLOGY.

TRANSLATED BY S. J. GOODFELLOW, M. D.

A. OF MUCUS.

Healthy mucus and mucus generated by irritation and normal inflammation, are composed of an amorphous ductile substance (proper mucus), globules, and epithelium.

HEALTHY MUCUS.	MUCUS PRODUCED BY NORMAL IRRITATION.	MUCUS PRODUCED BY SLIGHT NORMAL INFLAMMATION.	MUCUS PRODUCED BY A MORE INTENSE NORMAL INFLAMMATION.	MUCUS PRODUCED FROM CHRONIC NORMAL INFLAMMATION.
Very few globules	Very few globules	Globules more numerous	Globules very numerous	Globules very abundant
Much of an amorphous substance (proper mucus)	Very much of proper mucus	Less mucus	Much less mucus	Very little mucus
Contains but little epithelium	Contains but little of epithelium	Contains more epithelium	Contains very little epithelium	Contains very little epithelium
Globules from 2–4 times larger than the blood particles	Globules from 4–5 times larger than the blood particles	Globules 6–8 times larger than the blood particles	Globules from 6–8 times larger than the blood particles	Globules 6–8 times larger than the blood particles
No molecules, or the smallest, fill the globules	The smallest molecules fill the globules	The smallest molecules (filled with), and a central vesicle	Filled with the smallest molecules and a central vesicle	Filled with the smallest molecules and a central vesicle
Very thin envelope to the globules	Very thin smooth envelope	Smooth envelope	Smooth envelope	Smooth or no envelope
Not changed in water	Globules swell in distilled water	Swell in distilled water	Globules swell in distilled water	Swell in distilled water
		Envelopes easily broken in water	Envelopes easily broken	Envelopes easily broken

MUCUS ANALYSIS ... SO MANY IN ANOMALOUS INFLAMMATION CONTAINS, BESIDES SUBSTANCES PECULIAR TO
NORMAL MUCUS, OTHER FORMS.

MUCUS GENERATED FROM TUBERCULOUS INFLAMMATION OF THE LUNGS.	DYSENTERIC MUCUS.	MUCUS OF URETHRAL BLENNORRHŒA.
Besides the products of catarrhal inflammation contains yellow lenticular spheres 1-8 times larger than the globules of pus, concentrically striated, composed of concentric lamellæ, which are dissolved in caustic potash In nitric acid — solution of nitrate of silver { They are increased 5 times in volume and become transparent Some pulmonal cells and muscular fibres are seen in it	Contains globules with central vesicles and molecules, round or ovate greenish corpuscles endowed with the smallest molecules, symmetrically disposed, and also products of catarrhal inflammation	Contains from the beginning a very few globules exceeding four times the diameter of the particles of the blood, and provided with the smallest molecules and an envelope On the third day it is composed of many globules, the smallest molecules, an envelope, and central vesicle On the tenth day all the vesicles are endowed with central vesicles They swell and are easily broken in water On the fortieth day very few globules are found

B. OF PUS.

Pus is composed of a certain white pellucid fluid and globules; sometimes other substances are mixed with these.

PUS GENERATED BY NORMAL INFLAMMATION.

PUS FROM A RECENT WOUND.	PUS FROM A RECENT ABSCESS.	PUS FROM AN OLD ABSCESS.	PUS FROM AN OLD WOUND.	PUS FROM THE SURFACE OF AN ORGAN WHOSE CONTINUITY IS UNINJURED.
Few globules Contains more fluid Globules from 4-6 times larger than those of the blood With very small, and larger molecules Have one central vesicle and an envelope Globules swell, and envelope bursts in distilled water	Many globules Contains but little fluid Globules 3-4 times larger than those of the blood With very small, and larger molecules One or two central vesicles, seldom without one Globules swell, and envelope broken in distilled water	Many globules Contains but little fluid Globules 3-4 times larger than those of the blood With very small, and larger molecules With a central vesicle Swell but little in distilled water	Fewer globules But little fluid Globules 3-4 times larger than those of the blood Contains a good deal of epithelium With very small, and larger molecules No central vesicle Does not swell in distilled water	Fewer globules Much fluid Globules 6-8 times larger than those of the blood Contains but little epithelium With very small and larger molecules or none Composed of a central vesicle full of molecules, or none at all in it Sometimes swell in distilled water

PUS FROM SPECIFIC INFLAMMATION.

1. GENERATED DURING THE VARIOLOUS PROCESS.			2. GENERATED IN THE TUBERCULOUS PROCESS.
A. DURING THE FORMATION OF PAPULE.	B. DURING THE FORMATION OF VESICLES.	C. DURING THE FORMATION OF PUSTULES.	
The pellucid fluid extricated offers an alkaline reaction Is composed of a white pellucid fluid and a few free molecules of the larger and smallest kind, and animalcules On the third day after the eruption larger molecules and a few white almost pellucid globules 2-3 times larger than those of the blood Filled with the smallest molecules Molecular motion scarcely to be seen Animalculæ are found in it	On the 4th day a little limpid serum Contains globules endowed with the smallest and larger molecules, and a central vesicle The envelopes are not easily broken Vehement molecular motion Animalcules, and free very small globules On the 5th day the turbid serum has an alkaline reaction Contains globules of the larger yellow molecules The envelopes are easily broken The molecular motion and animalcules are well seen	On the 6th day the thicker yellow fluid has but a slight alkaline reaction The globules 4 times larger than those of the blood, many with an envelope easily to be broken or without one Filled with the smallest or the larger molecules, and sometimes provided with a central vesicle The molecular motion diminished On the 7th day and beyond, the yellow thick fluid contains many globules adhering together The envelopes are very easily broken, the molecules dissipated without order Cells of epithelium and drops of fat are frequently seen in it	See—Mucus produced from Specific Inflammation.

N.B.—In some individuals the globules are 3-4 times larger than those of the blood, perfectly or partly empty, also spheres twice or six times larger than the pus globules, consisting of smaller spherules.

C. OF SEROUS EXUDATION.

WHITE, OR GREENISH-WHITE, LIMPID, EXUDATED, SEROUS FLUID IS COMPOSED OF A PELLUCID FLUID AND GLOBULES.

SEROUS EXUDATION OF A BLADDER PRODUCED BY BLISTER.	SEROUS EXUDATION FROM CRUDE INFILTRATION OF INTESTINAL TYPHUS.	SEROUS EXUDATION EXTRICATED FROM THE PAPULE OF MODIFIED VARIOLA.	SEROUS EXUDATION EXTRACTED FROM THE FIBRINE OF A VILLOUS HEART.	SEROUS EXUDATION FROM A HYDROCYST.	SEROUS EXUDATION FROM ŒDEMA OF THE CUTIS.	SEROUS EXUDATION EXTRACTED FROM THE SUBSTANCE OF AN INFLAMED HUMAN PLACENTA.	SEROUS EXUDATION FROM THE VAGINAL DISCHARGE ON THE THIRD PERIOD OF PREGNANCY.
Contains white globules with a very thin covering filled with the smallest molecules, or destitute of all covering 1-2 larger than the blood globules	Contains white globules with an envelope filled with the smallest molecules 1-2 larger than the blood globules	Contains white globules with a very thin covering filled with the smallest molecules 1-4 times larger than the blood globules	Contains white globules, consisting of a very thin envelope, filled with the smallest molecules 1-2 times larger than those of the blood	Contains perfectly round white globules destitute of molecules Scarcely larger than the globules of the blood	Contains white, or yellowish-white stellated globules, scarcely larger than those of the blood Here and there provided with a small nucleus	Contains white globules, with an envelope filled with the smallest molecules 1-2 times larger than those of the blood	Contains white globules, with an envelope filled with the smallest molecules Once to twice larger than the blood discs

D. THE MORPHOLOGY OF THE GLOBULES GENERATED DURING THE PATHOLOGICAL PROCESS.

1. THOSE WHICH OCCUR IN MUCOUS MEMBRANE.

IN HEALTHY MUCOUS MEMBRANE.	IN IRRITATED MUCOUS MEMBRANE.	IN SLIGHTLY IRRITATED MUCOUS MEMBRANE.	IN A MORE INTENSE INFLAMMATION OF MUCOUS MEMBRANE.	IN CHRONIC INFLAMMATION OF A MUCOUS MEMBRANE.
Very few yellowish-white globules are generated provided with a covering, and enclosing none or very few of the smallest er molecules They are not changed in water, and are from 2-4 times larger than those of the blood	Very few yellowish-white globules are generated They are provided with an envelope, enclosing the smallest molecules, and are 4 times larger than the blood globules, and swell in water	More copious or abundant yellowish-white globules are generated. They are provided with an envelope, filled with the smallest molecules and a central vesicle, and swell, and are broken in water. They are 8 times larger than the blood globules	The yellow globules are generated in greater abundance, 8 times larger than the blood globules, endowed with an envelope, filled with the smallest molecules, and a central vesicle They swell, and are broken, in water	The yellow globules are generated in the greatest abundance, are 8 times larger than the blood globules, endowed with an envelope, or an envelope with the smallest molecules, and a central vesicle

2. THOSE WHICH ARE GENERATED IN THE SKIN.

BY THE APPLICATION OF A BLISTER.	BY THE VARIOLOUS PROCESS UNDER THE FORMATION OF PAPULE.	BY THE VARIOLOUS PROCESS DURING THE FORMATION OF VESICLES.	BY THE VARIOLOUS PROCESS DURING THE FORMATION OF PUSTULES.	BY THE VARIOLOUS PROCESS DURING THE FORMATION OF CRUSTS.
A very few white globules, 2–3 times larger than the blood globules, endowed with no envelope, or one filled with the smallest molecules. Water does not change them	A very few white globules, 2–3 times larger than those of the blood, pellucid, endowed with a very thin covering, enclosing the smallest molecules. They swell in water	Numerous yellowish-white globules, 3–4 times larger than those of the blood, endowed with an envelope, filled with the smallest and larger molecules, and a central vesicle. They swell, and are broken, in the water	Very numerous yellow globules, 4–5 times larger than those of the blood, provided with the smallest and larger molecules, and the central vesicle. They swell in water, and are easily broken	A few yellow whole globules, 4–5 times larger than those of the blood: many lacerated, furnished with no envelope, or with one filled with the different molecules. They are easily broken

3. THOSE WHICH ARE GENERATED IN SEROUS MEMBRANE.

HYDROCYSTIS.	OF THE PERICARDIUM UNDER THE FORMATION OF THE VILLOUS HEART.	OF AN INFLAMED PERITONEUM.	OF AN INFLAMED PERITONEUM NEONATI.	OF A VERY ACUTELY INFLAMED PERITONEUL.
White, pellucid, perfectly round globules are formed, scarcely larger than those of the blood, with an envelope destitute of all molecules. They are not changed in water	White globules, 2–3 times larger than those of the blood, endowed with a very thin envelope, filled with the smallest molecules. They swell in water	Yellowish-white globules, 3–6 times larger than those of the blood, formed with an envelope, filled with the smallest and larger molecules. They swell in water	Yellowish-white globules, 4–8 times larger than those of the blood, composed of a very fine envelope, with a few very small molecules or none, and with a central vesicle, either filled with the smallest molecules, or possessing none. They are not changed by water	Yellow globules, 4–8 times larger than those of the blood, either with a very thin envelope partly or entirely filled with the smallest or larger molecules, or with no envelope. They are not changed by water

THOSE WHICH ARE GENERATED IN PATHOLOGICAL (DISEASED) PARENCHYMA.

OF CRUDE, RECENT INFILTRATION OF THE ILEUM.	OF THE RED INFILTRATED MESENTERIC GLANDS IN ABDOMINAL TYPHUS.	IN THE PROCESS OF PURULENT INFILTRATION OF THE CELLULAR TISSUE.	IN THE SOFTENED MESENTERIC GLANDS IN ABDOMINAL TYPHUS.
The globules are white, diaphanous, scarcely exceeding the diameter of the blood globules, with a smooth envelope filled with the smallest molecules. They swell but little in water	Yellowish-white diaphanous globules exceeding from 2-4 the globules of the blood, composed of an envelope filled with the smallest molecules, or 6 times larger than those of the blood, with an envelope filled with the smallest molecules and a central vesicle, are many molecules	Round yellowish-white globules, exceeding 4 times the magnitude of those of the blood, composed of an envelope filled with the smallest molecules. They swell but little in water	Round yellowish-white globules 4-8 times larger than those of the blood, composed of an envelope with the smallest or larger molecules. They swell in water
OF A HEPATIZED RECENT PLACENTA.		IN THE EXUDATION OF PLASTIC LYMPH IN CROUP.	
White globules scarcely exceeding those of the blood, composed of an envelope, filled with the smallest molecules		Round yellowish-white globules exceeding 3 or 4 times the size of those of the blood, composed of an envelope filled with very small molecules. They are not changed by water	
OF A HEPATIZED SPLEEN.			
White globules equalling in magnitude the globules of the blood, or twice as large, with or without an envelope, but if with one it is filled with the smallest molecules. They are not changed by water			

THOSE WHICH ARE GENERATED ON THE SURFACE OF A PATHOLOGICAL (DISEASED) ORGAN.

EXPOSED.

IN THE TENTH HOUR OF A RECENT WOUND.	OF PUS OF A RECENT WOUND 24 HOURS AND BEYOND.	OF PUS IN THE SEVENTH WEEK OF A RECENT WOUND.	FROM AN OLD WOUND SUPPURATING BUT LITTLE.
A few round, white, transparent globules 1-3 times larger than those of the blood, composed of a very thin envelope filled with the smallest molecules. They swell but little in water	Round yellowish-white abundant globules 4-6 times larger than those of the blood, endowed with a very thin envelope with the smallest and the larger molecules, and also a central vesicle. They swell in water	Very numerous round yellowish globules 5-8 times larger than those of the blood, composed of an envelope with the smallest molecules and a central vesicle. They swell and their envelopes are broken in water	A few yellow roundish globules 2-4 times larger than those of the blood, composed of a dense envelope full of the smallest molecules. They are not changed by water

SHUT.

ABSCESSUS IDIOPATHICI RECENTISSIMI PRELI ABDOMINALIS.	OF IDIOPATHIC ABSCESS OF THE LIVER.	OF AN OLD IDIOPATHIC ABSCESS.	OF A METASTATIC ABSCESS OF SIX DAYS' STANDING.
Round or oblong yellow globules 4-6 times larger than those of the blood, composed of a very thin envelope, with the very small and larger molecules, either with or without a central vesicle, or a simple or double one. They swell in water and their envelopes burst	Round yellow globules 3 - 4 times larger than those of the blood, composed of a thin envelope full of the larger and a few of the largest molecules. They are changed but little in water	Yellow round globules 4-6 times larger than those of the blood, composed of a very thin envelope, endowed with the smallest molecules: some have no envelope. They swell in water	Round globules 1-3 times larger than those of the blood, composed of the smallest molecules, but seldom of an envelope. Are not changed by water

COMPARISON BETWEEN MUCUS AND PUS GENERATED FROM NORMAL INFLAMMATION.

MUCUS IS COMPOSED	FORM OF THE GLOBULES.	MAGNITUDE.	COLOUR.	ENVELOPE.	CENTRAL VESICLE.	MOLECULES.	DISTILLED WATER.	ACETIC ACID.	OXALIC ACID.	TARTARIC ACID.	NITRIC ACID.	MURIATIC ACID.	SOLUTION OF THE NITRATE OF SILVER.	CONCENTRATED SOL. OF NITRATE OF SILVER.	PURE AMMONIA.	LIME WATER.	PURE POTASH.	SPIRITS OF WINE.
1. Of Globules.	Round	6-8 times larger than those of the blood	White or yellow	Smooth	Single or double	The very small and the larger	Enve-lopes are broken	Dis-solves the en-velopes and the very small mole-cules. — The nuclei 1-6 re-main clearly to be seen	Dis-solves the en-velopes and the very small mole-cules.	Quick-ly dis-solves the en-velopes, the white vesicle remain-ing	Corru-gates the en-velopes	Corru-gates the en-velopes	Corru-gates the glo-bules, and tinges them of a yellow colour	First dis-solves the en-velopes, more slowly the very small mole-cules and nuclei	No change	No change	Dis-solves the globu-les; the white mu-cous fluid re-mains	Con-tracts the globu-les
2. Of the thick pellucid ductile fluid.																		
3. Of Epithelium.								No change pro-duced	No change pro-duced	No change pro-duced	Forms fila-ments	Forms fila-ments		Forms fila-ments, which are more slowly dis-solved in it				

	FORM OF THE GLOBULES.	MAGNITUDE.	COLOUR.	ENVELOPE.	CENTRAL VESICLE.	MOLECULES.	DISTILLED WATER.	ACETIC ACID.	OXALIC ACID.	TARTARIC ACID.	NITRIC ACID.	MURIATIC ACID.	SOLUTION OF THE NITRATE OF SILVER.	CONCENTRATED SOL. OF NITRATE OF SILVER.	PURE AMMONIA.	LIME WATER.	PURE POTASH.	SPIRITS OF WINE.
PUS IS COMPOSED — 1. Of Globules. 2. Of a pellucid fluid.	Round or ob-long	3–4 times longer than those of the blood	White or yellow	Smooth or none at all	One or two, sel-dom none	The very small and the larger	Enve-lopes are bro-ken	Dis-solves the en-velopes, the 2-5 nuclei remain	Dis-solves the en-velopes, the 2-5 nuclei remain	Very quickly dis-solves the enve-lopes	Corru-gates the enve-lopes	Corru-gates the enve-lopes	Corru-gates the globu-les, and gives them a yellow tinge	Ren-ders the glo-bules trans-parent, the con-tracted nucleus remain-ing	No change	No change	Dis-solves the glo-bules, the mu-cous fluid remain-ing	Con-tracts the globu-les, and forms from 1-5 nuclei
3. Some-times of cells of Epithelium.								Pro-duces no change	Pro-duces no change	Pro-duces no change	Forms no fila-ments	Forms no fila-ments	Forms no fila-ments	Forms no fila-ments				

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